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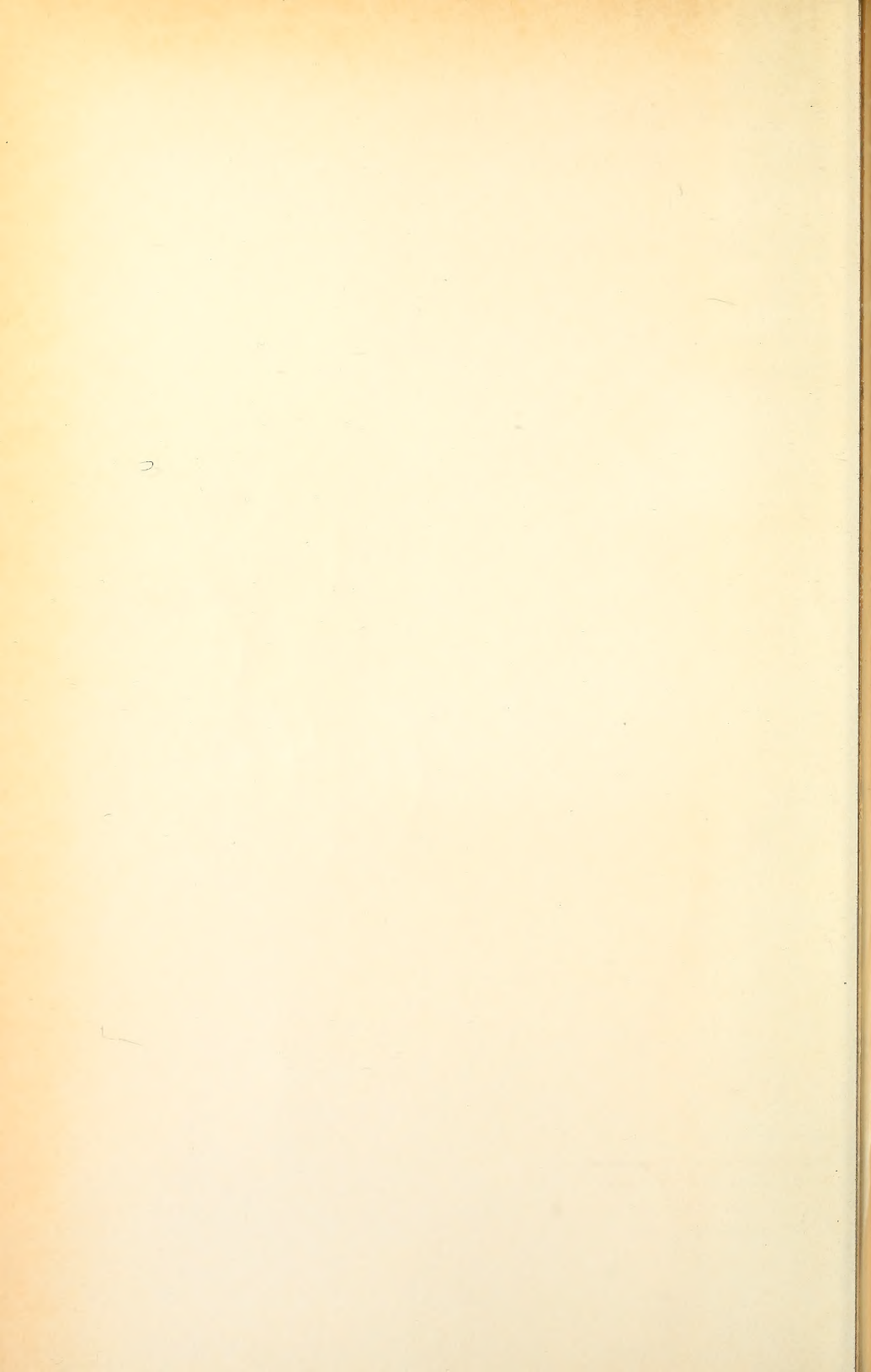


1978-1979

The Pennsylvania State University Bulletin

Graduate Degree Programs

Betty Welch
401 Pattee
Penn State



1978-1979

THE PENNSYLVANIA STATE UNIVERSITY

GRADUATE DEGREE PROGRAMS

**GENERAL CATALOG
SEPTEMBER 1978**

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THE PENNSYLVANIA STATE UNIVERSITY BULLETIN

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REGULATIONS SUBJECT TO CHANGE

The educational process necessitates change. This bulletin must be considered as informational and not binding on the University.

Each step of the educational process, from admission through graduation, requires continuing review and appropriate approval by University officials. The University, therefore, reserves the right to change the requirements and regulations contained in this bulletin and to determine whether a student has satisfactorily met its requirements for admission or graduation, and to reject any applicant for admission for any reason the University determines to be material to the applicant's qualification to pursue higher education.

GRADUATE CALENDAR*

FALL TERM 1978

JULY 1978

- 31 Monday — Last date for a prospective graduate student to submit completed application materials for admission to the fall term 1978
- 31 Monday — Last date for a graduate student to apply for permission to resume study in the fall term 1978

AUGUST AND SEPTEMBER

- 30-1 Wednesday noon to Friday — Fall term registration
- 4 Monday — Labor Day holiday
- 5 Tuesday — Fall term classes begin 8:00 A.M.
- 8 Friday — Last date for registering with foreign language departments (other than French and Spanish) for written language examinations
- 18 Monday — Last date for a November graduate to activate diploma card in Registrar's Office *and* to pay thesis fee at Bursar's Office
- 26 Tuesday — Last date for written foreign language examinations (other than French and Spanish) for advanced-degree candidates
- 30 Saturday — Last date for a November graduate to deliver doctoral thesis to committee

OCTOBER

- 7 Saturday — Last date for final oral doctoral examinations for November graduates
- 7 Saturday — Last date for a November graduate to deliver master's thesis or paper to adviser
- 23 Monday — Last date for a November graduate to deliver thesis to Graduate School Office
- 23 Monday — Last date for departments to certify to Graduate School completion of required papers for November graduates
- 23 Monday — Last date for a November graduate to order cap, gown, and hood locally

NOVEMBER

- 11 Saturday — Last date for submitting a petition to the records officer to graduate *in absentia* in November
- 13 Monday — Fall term classes end 9:55 P.M.
- 14-18 Tuesday to Saturday noon — Final examinations
- 23 Thursday — Thanksgiving Day holiday
- 26 Sunday — Commencement

*This calendar is subject to change without notice. In preparing the calendar for an academic year, the University makes every effort to avoid conflicts with religious holidays. However, such conflicts are sometimes unavoidable. When they occur, efforts are made to make special arrangements for the students affected.

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Examination Services, 207 Mitchell Building. Times and places of tests will be announced when the application is filed.

WINTER TERM 1979

OCTOBER 1978

- 30 Monday — Last date for a prospective graduate student to submit completed application materials for admission to the winter term 1979
- 30 Monday — Last date for a graduate student to apply for permission to resume study in the winter term 1979

NOVEMBER

- 28, 29 Tuesday, Wednesday — Winter term registration
- 30 Thursday — Winter term classes begin 8:00 A.M.

DECEMBER

- 6 Wednesday — Last date for registering with foreign language departments (other than French and Spanish) for written language examinations
- 11 Monday — Last date for a March graduate to activate diploma card in Registrar's Office *and* to pay thesis fee at Bursar's Office
- 19 Tuesday — Winter term recess begins 9:55 P.M.

JANUARY 1979

- 2 Tuesday — Winter term recess ends
- 3 Wednesday — Winter term classes resume 8:00 A.M.
- 4 Thursday — Last date for written foreign language examinations (other than French and Spanish) for advanced-degree candidates
- 6 Saturday — Last date for a March graduate to deliver doctoral thesis to committee
- 13 Saturday — Last date for final oral doctoral examinations for March graduates
- 13 Saturday — Last date for a March graduate to deliver master's thesis or paper to adviser
- 29 Monday — Last date for a March graduate to deliver thesis to Graduate School
- 29 Monday — Last date for department to certify to Graduate School completion of required papers for March graduates
- 29 Monday — Last date for a March graduate to order cap, gown, and hood locally

FEBRUARY

- 17 Saturday — Last date for submitting a petition to the records officer to graduate *in absentia* in March
- 21 Wednesday — Winter term classes end 9:55 P.M.
- 22-24, 26 Thursday to Saturday, Monday — Final examinations

MARCH

- 3 Saturday — Commencement

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Examination Services, 207 Mitchell Building. Times and places of tests will be announced when the application is filed.

SPRING TERM 1979

FEBRUARY 1979

- 6 Tuesday — Last date for a prospective graduate student to submit completed application materials for admission to the spring term 1979
- 6 Tuesday — Last date for a graduate student to apply for permission to resume study in the spring term 1979

MARCH

- 6, 7 Tuesday, Wednesday — Spring term registration
- 8 Thursday — Spring term classes begin 8:00 A.M.
- 14 Wednesday — Last date for registering with foreign language departments (other than French and Spanish) for written language examinations
- 19 Monday — Last date for a May graduate to activate diploma card in Registrar's Office and to pay thesis fee at Bursar's Office
- 31 Saturday — Last date for a May graduate to deliver doctoral thesis to committee

APRIL

- 3 Tuesday — Last date for written foreign language examinations (other than French and Spanish) for advanced-degree candidates
- 7 Saturday — Last date for final oral doctoral examinations for May graduates
- 7 Saturday — Last date for a May graduate to deliver master's thesis or paper to adviser
- 23 Monday — Last date for a May graduate to deliver thesis to Graduate School
- 23 Monday — Last date for departments to certify to Graduate School completion of required papers for May graduates
- 23 Monday — Last date for a May graduate to order cap, gown, and hood locally

MAY

- 12 Saturday — Last date for submitting a petition to the records officer to graduate *in absentia* in May
- 16 Wednesday — Spring term classes end 9:55 P.M.
- 17-19, 21 Thursday to Saturday, Monday — Final examinations
- 26 Saturday — Commencement

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Examination Services, 207 Mitchell Building. Times and places of tests will be announced when the application is filed.

SUMMER TERM 1979

MAY 1979

- 4 Friday — Last date for a prospective graduate student to submit completed application materials for the summer term 1979
- 4 Friday — Last date for a graduate student to apply for permission to resume study in the summer term 1979

JUNE

- 5 Tuesday — Summer term registration
- 6 Wednesday — Summer term classes begin 8:00 A.M.
- 12 Tuesday — Last date for registering with foreign language departments (other than French and Spanish) for written language examinations
- 18 Monday — Last date for an August graduate to activate diploma card in Registrar's Office *and* to pay thesis fee at Bursar's Office
- 30 Saturday — Last date for an August graduate to deliver doctoral thesis to committee

JULY

- 3 Tuesday — Last date for written foreign language examinations (other than French and Spanish) for advanced-degree candidates
- 4 Wednesday — Independence Day holiday
- 7 Saturday — Last date for final oral doctoral examinations for August graduates
- 7 Saturday — Last date for an August graduate to deliver master's thesis or paper to adviser
- 23 Monday — Last date for an August graduate to deliver thesis to Graduate School
- 23 Monday — Last date for departments to certify to Graduate School completion of required papers for August graduates
- 23 Monday — Last date for an August graduate to order cap, gown, and hood locally

AUGUST

- 11 Saturday — Last date for submitting a petition to the records officer to graduate *in absentia* in August
- 15 Wednesday — Summer term classes end 9:55 P.M.
- 16-18 Thursday to Saturday — Final examinations
- 25 Saturday — Commencement

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Examination Services, 207 Mitchell Building. Times and places of tests will be announced when the application is filed.

FALL TERM 1979

JULY 1979

- 30 Monday — Last date for a prospective graduate student to submit completed application materials for admission to the fall term 1979
- 30 Monday — Last date for a graduate student to apply for permission to resume study in the fall term 1979

AUGUST

- 29-31 Wednesday noon to Friday — Fall term registration

SEPTEMBER

- 3 Monday — Labor Day holiday
- 4 Tuesday — Fall term classes begin 8:00 A.M.
- 7 Friday — Last date for registering with foreign language departments (other than French and Spanish) for written language examinations
- 17 Monday — Last date for a November graduate to activate diploma card in Registrar's Office *and* to pay thesis fee at Bursar's Office
- 25 Tuesday — Last date for written foreign language examinations (other than French and Spanish) for advanced-degree candidates
- 29 Saturday — Last date for a November graduate to deliver doctoral thesis to committee

OCTOBER

- 6 Saturday — Last date for final oral doctoral examinations for November graduates
- 6 Saturday — Last date for a November graduate to deliver master's thesis or paper to adviser
- 22 Monday — Last date for a November graduate to deliver thesis to Graduate School
- 22 Monday — Last date for departments to certify to Graduate School completion of required papers for November graduates
- 22 Monday — Last date for a November graduate to order cap, gown, and hood locally

NOVEMBER

- 10 Saturday — Last date for submitting a petition to the records officer to graduate *in absentia* in November
- 12 Monday — Fall term classes end 9:55 P.M.
- 13-17 Tuesday to Saturday noon — Final examinations
- 22 Thursday — Thanksgiving Day holiday
- 25 Sunday — Commencement

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Examination Services, 207 Mitchell Building. Times and places of tests will be announced when the application is filed.

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*Printer deadlines prohibit changes in the Graduate Faculty listings under graduate major programs after March 15, 1978.

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 EUGENE G. WILLIAMS, Ph.D. (Penn State) *Professor of Geology*
 FREDERICK M. WILLIAMS, Ph.D. (Yale) *Associate Professor of Biology*
 ROBERT J. WILLIAMS, Ph.D. (Wisconsin) *Assistant Professor of Mechanical Engineering*
 WILLIAM WILLIAMS, D.Ed. (Penn State) *Assistant Professor of Agricultural Education*
 JANET A. WILLIAMSON, Ph.D. (Penn State) *Associate Professor of Nursing*
 SHERRY L. WILLIS, Ph.D. (Texas) *Assistant Professor of Early Childhood Education*
 FERN K. WILLITS, Ph.D. (Penn State) *Professor of Rural Sociology*
 DONALD J. WILLOWER, Ed.D. (Buffalo) *Professor of Education*
 BRENT G. WILSON, Ph.D. (Ohio State) *Professor of Art Education*
 DAVID T. WILSON, Ph.D. (Western Ontario) *Professor of Marketing*
 GEOFFREY L. WILSON, Ph.D. (Loughborough Tech., England), P.E. *Associate Professor of Engineering Research*
 LOWELL L. WILSON, Ph.D. (South Dakota State) *Professor of Animal Science*
 R. DALE WILSON, Ph.D. (Iowa) *Assistant Professor of Marketing*
 LOUIS WINKLER, Ph.D. (Pennsylvania) *Assistant Professor of Astronomy*
 JERRY L. WIRCENSKI, Ph.D. (Ohio State) *Associate Professor of Vocational Education*
 JOHN WITHALE, Ph.D. (Chicago) *Professor of Education and Educational Psychology*
 FRANCIS H. WITHAM, Ph.D. (Indiana) *Associate Professor of Biology*
 WILLARD E. WITTE, Ph.D. (Wisconsin) *Assistant Professor of Economics*
 WARREN F. WITZIG, Ph.D. (Pittsburgh) *Professor of Nuclear Engineering*
 JOACHIM F. WOHLWILL, Ph.D. (California) *Prof. of Man-Environment Relations and Psychology*
 GEORGE D. WOLF, Ph.D. (Pennsylvania) *Professor of American Studies and History*
 MELVIN H. WOLF, Ph.D. (Michigan) *Professor of Humanities and English*
 CARL H. WOLGEMUTH, Ph.D. (Ohio State) *Professor of Mechanical Engineering*
 IRA WOLINSKY, Ph.D. (Kansas) *Associate Professor of Nutrition*
 FRED H. WOOD, D.Ed. (Missouri) *Professor of Education*
 NORMAN D. WOOD, Ph.D. (Brigham Young) *Assistant Professor of Education*
 DAWN CLAUDIA WOODERSON, Ph.D. (Florida State) *Assistant Professor of Music Education*

LLOYD W. WOODRUFF, Ph.D. (Minnesota) *Associate Professor of Public Administration*
 PAUL O. WOOLLEY, JR., M.D. (Yale) *Associate Professor of Health Planning*
 DETLEF WOTSCHKE, Ph.D. (California) *Assistant Professor of Computer Science*
 HELEN S. WRIGHT, Ph.D. (Penn State) *Associate Professor of Nutrition*
 JAMES E. WRIGHT, JR., Ph.D. (Cornell) *Professor of Genetics*
 LAUREN A. WRIGHT, Ph.D. (California Tech.) *Professor of Geology*
 PAUL J. WUEST, Ph.D. (Penn State) *Professor of Plant Pathology*
 JOSEPH P. YANEY, Ph.D. (Michigan) *Professor of Business Administration*
 RONALD E. YASBIN, Ph.D. (Rochester) *Asst. Professor of Microbiology and Cell Biology*
 THOMAS D. YAWKEY, Ph.D. (Illinois) *Associate Professor of Education*
 WILLIAM G. YENDOL, Ph.D. (Purdue) *Professor of Entomology*
 BERTRAM YOOD, Ph.D. (Yale) *Professor of Mathematics*
 THOMAS M. YORK, Ph.D. (Princeton) *Associate Professor of Aerospace Engineering*
 CARL E. YOUNG, Ph.D. (George Peabody) *Assistant Professor of Human Development*
 DAVID L. YOUNG, M.L.A. (Harvard) *Professor of Landscape Architecture*
 FREDERICK J. YOUNG, Ph.D. (Carnegie Tech.) *Professor of Electrical Engineering*
 PHILIP YOUNG, Ph.D. (Iowa) *Research Professor of English*
 FRANKLIN R. ZABRISKIE, Ph.D. (Princeton) *Associate Professor of Astronomy*
 JOSEPH ZAFFORONI, Ed.D. (Columbia) *Professor of Education*
 IAN S. ZAGON, Ph.D. (Colorado) *Assistant Professor of Anatomy*
 CARLOS ZAMORA, Ph.D. (U.C.L.A.) *Assistant Professor of Spanish*
 SAM Y. ZAMRIK, Ph.D. (Penn State) *Professor of Engineering Mechanics*
 ERIC J. ZANOT, Ph.D. (Illinois) *Assistant Professor of Advertising*
 ARIAN ZARKOWER, Ph.D. (Cornell) *Associate Professor of Veterinary Science*
 WILBUR ZELINSKY, Ph.D. (California) *Professor of Geography*
 ROBERT F. ZELIS, M.D. (Chicago) *Professor of Medicine and Physiology*
 JOHN H. ZIEGLER, JR., Ph.D. (Penn State) *Professor of Meat Science*
 VICKIE L. ZIEGLER, Ph.D. (Yale) *Associate Professor of German*
 LEONARD N. ZIMMERMAN, Ph.D. (Cornell) *Professor of Bacteriology*
 RICHARD E. ZINDLER, Ph.D. (Michigan State) *Professor of Engineering Research*
 HARRY D. ZOOK, Ph.D. (Penn State) *Professor of Chemistry*
 GEORGE S. ZORETICH, M.A. (Penn State) *Professor of Art*

GENERAL INFORMATION

GENERAL INFORMATION

THE GRADUATE SCHOOL

Graduate work at The Pennsylvania State University was first offered in 1862, but for some time there were few graduate students and graduate instruction was relatively unorganized. A committee of the General Faculty eventually was given the responsibility of establishing standards and regulations governing graduate work and the granting of master's and certain technical degrees. The Graduate School was formally established in 1922 by the President and the Board of Trustees. An administrative staff was organized, and the Graduate Faculty was formed. The University Senate delegated to this faculty responsibility for graduate affairs, subject to review. In 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy. On May 9, 1971, a Graduate Council was established for the Graduate School. Today graduate study is offered in 126 major programs, with 17 advanced academic and professional degrees being conferred. During the academic year 1976-1977, 6,100 to 6,600 graduate students were enrolled each term, and 1,751 advanced degrees were conferred, of which 403 were doctorates.

The Graduate School is a member of the Association of Graduate Schools (an organization within the Association of American Universities) and of the Council of Graduate Schools in the United States.

MAJOR ROLE

The major role of the Graduate School is to emphasize those aspects of University activity which pertain directly to major programs in graduate study. Through its Graduate Faculty it represents a large segment of the academic strength of the University and is thus a dominant force in sustaining and furthering the intellectual quality of the entire institution. The eleven colleges of the University formulate study and research programs appropriate to their fields. The Graduate Faculty consists of those members of the college faculties who have authorization through the Graduate School to offer courses and seminars and supervise research and theses consistent with the highest academic standards. Thus, the Graduate School may be regarded as a federation of selected segments of the college faculties.

GOVERNANCE

The governance of the Graduate School is vested in a Graduate Council, whose legislative authority is subject to the specific restrictions of the "Articles of Authority." The council forms its own committee structure under bylaws outlined in "Standing Rules of the University Graduate Council."

Executive and administrative matters of the Graduate School are the responsibility of the dean, who is charged directly with enforcement of the regulations of the Graduate School and with organization of its administrative procedures. The dean has a major responsibility to enhance and insure the high quality of graduate study and research of graduate students. He exercises leadership in initiating new programs and in restructuring or phasing out marginal and obsolete ones. The dean encourages and assists in the development of multidisciplinary programs. He is assisted in this work by an administrative and clerical staff.

ADMINISTRATIVE DIVISIONS

There are four major administrative divisions in the Graduate School to which the students may go directly for answers to questions which require administrative assistance or decisions:

1. *Graduate Admissions*, 201 Kern Graduate Building. The Office of Graduate Admissions has responsibility for processing all matters pertaining to a student's admission.
2. *Graduate Student Programs*, 211 Kern Graduate Building. The functions of the Office of Graduate Student Programs encompass responsibilities for the academic involvement and concerns of all graduate students from the time they are admitted until they graduate, such as: (a) registration of students, (b) readmission of students, (c) maintenance of records, (d) appointment of graduate committees for doctoral students, (e) scheduling of graduate student comprehensive examinations, (f) checking for accomplishment by students of Graduate Faculty requirements for all advanced degrees and preparation of official commencement lists, and (g) attention to student academic problems.
3. *Graduate Fellowships*, 320 Kern Graduate Building. The Office of Graduate Fellowships serves as a clearinghouse for information on available fellowships and other awards for

- graduate students, administers fellowships and other award programs involving students in more than one college, and seeks support for graduate students attending the University.
4. *Theses and Publications*, 320 Kern Graduate Building. The Office of Theses and Publications is responsible for reviewing all theses to assure that they meet format requirements consistent with the attainment of high scholarly standards. The office prepares the major Graduate School publications.

PROGRAMS AT OTHER LOCATIONS

Behrend College — The Behrend College at Erie provides convenient opportunity for graduate education to persons residing in northwestern Pennsylvania. It has been established to offer individual courses and a program leading to the degree of Master of Engineering with a major in engineering science.

King of Prussia Graduate Center — The King of Prussia Graduate Center near Philadelphia offers programs leading to the degrees of Master of Engineering with majors in engineering science and industrial engineering, and Master of Education with a major in mathematics.

The Capitol Campus — The Capitol Campus, located near Middletown and named for its proximity to the state capital, was opened in 1966. Graduate programs leading to the degrees of Master of Administration, Master of Arts with majors in American studies and in humanities, Master of Education with a major in teaching and curriculum, Master of Engineering with a major in engineering science, Master of Psychosocial Science, Master of Public Administration, and Master of Regional Planning with a major in urban and regional planning are currently offered.

The Milton S. Hershey Medical Center — The University's Medical Center was established in 1963, and the first class of medical students entered in the fall of 1967. The center is located in Hershey, Pennsylvania, twelve miles from Harrisburg. In conjunction with The Pennsylvania State University's Graduate School, the College of Medicine offers programs leading to the Master of Science degree with a major in laboratory animal medicine, and to the Doctor of Philosophy and Master of Science degrees with majors in anatomy, biological chemistry, microbiology, pharmacology, and the intercollegiate programs in genetics and physiology.

KERN GRADUATE BUILDING

The Kern Graduate Building is named in honor of the late Dean Emeritus Frank D. Kern, who was the first dean of the Graduate School. The Graduate School administrative offices are on the second and third floors of the building.

GRADUATE COMMONS

The Graduate Commons, located on the first floor of Kern Graduate Building, provides programs, services, and facilities for the graduate community and serves as a common meeting area for faculty and students. The assembly room and multipurpose rooms are used for large group meetings; the smaller rooms are used for committee meetings and similar small group gatherings. These may be reserved by graduate organizations or for events of a University-wide nature.

Food service is provided by the Department of Housing and Food Service in the cafeteria and for special catered events. The lobby contains the Commons Gallery, which displays artwork done by

students and faculty and exhibits from sources outside the University. The Commons serves as the home for Graduate Student Association programs such as the coffeehouse, films, concerts, and similar events. Policy governing building use and services is determined by the Graduate Council Committee on Graduate Commons and Related Matters.

The Office of the Director of the Graduate Commons serves as a clearinghouse for the scheduling of events planned by organizations and individuals. Reservations, a periodicals lending library (including daily newspapers), information regarding Graduate Commons activities, recreational equipment, and information of a general nature concerning the Graduate School are available at the Graduate Commons Information Desk. The Commons is open seven days a week during the term session. The operating hours are posted at building entrances. For further information call the Information Desk at 865-1878.

INTERNATIONAL STUDENT LOUNGE

The Office of International Student Affairs (OISA) and the International Student Lounge are located in 111 Kern Graduate Building. There are approximately 1,000 international students from 95 countries studying at the various University campuses. The majority of these students are enrolled in graduate programs.

Services of OISA include: assistance with immigration regulations and tax information; academic and personal/social counseling; emergency loans; program advising; mail service; housing information; job and travel information; job information in home countries; an international student newsletter; and sponsorship of many clubs and activities.

The International Student Lounge is a comfortable place for international and American students to meet informally. All students are welcome to participate in OISA activities. Announcements of events are posted regularly in the lounge. OISA maintains a library of overseas work/study/travel information, as well as other educational reading materials, including dictionaries, encyclopedias, maps, arts and crafts books, and many newspapers and magazines from around the world. The lounge and conference room are available for group meetings upon request.

The OISA works closely with the Community International Hospitality Council, a local community volunteer organization, and the International Council, a student organization which represents international students to the University administration and promotes a variety of social, cultural, and educational programs for the University community.

GRADUATE STUDENT ASSOCIATION

The Graduate Student Association was established in 1951 as the official voice of graduate students, all of whom are automatically members. It is the particular function of the organization to give to the individual member the opportunity to stimulate student intellectual interests and to bring to light problems and resolve them through discussion and collective action. It provides the occasion for relaxation through its social program. To help defray expenses, the association is partially funded through an allocation from Associated Student Activities, which is under the direction of the assistant vice president for student programs.

The Graduate Student Association Council, the legislative arm of the association, consists of elected delegates from every graduate department, with voting rights proportionate to the number of students in the department. Also included as voting *ex officio* members are the graduate students who have been elected to serve on the University Faculty Senate (4), the Graduate Council (5), and the University Council (1). All members of the University community are invited to attend the regular monthly meetings of the Association Council. An Executive Board, which consists of the executive officers and division heads, has interim powers to conduct business not requiring the specific action of the Association Council. The executive officers act as official liaison between the association and the dean of the Graduate School.

The Graduate Student Association has an office in 305 Kern Graduate Building (Tel. 865-9061). It has established the following divisions and standing committees: *Service Division* (1) Housing

Committee, (2) Publication Committee, (3) Health Committee, (4) Tax Committee, and (5) Orientation Committee; *Programming/Planning Division* (1) Coffeehouse Committee, (2) Film Committee, (3) Speakers and Workshop Committee, and (4) Special Events Committee; *Academic Division*; and *Rules Committee*.

In addition, the Association Council may institute *ad hoc* committees and presidential commissions at will. Graduate students are eligible to serve on all committees of the Graduate Council.

The association maintains communication among its members through the campus daily newspaper, scheduled meetings and workshops, and informal use of the Graduate Commons. It publishes annually the *Guide to Graduate Life*, an informal introduction to both the University and the community.

FACILITIES

THE UNIVERSITY LIBRARIES

The University Libraries include a central collection, six special subject libraries, and one reading room at University Park. Libraries are also located at Hershey Medical Center, Capitol Campus, King of Prussia Graduate Center, Behrend College, and at each of the seventeen Commonwealth Campuses.

At University Park, the central collection, the Arts Library, and the Life Sciences Library are all housed in the Fred Lewis Pattee Library. There are four branch libraries serving the Colleges of Earth and Mineral Sciences, Engineering, Science, and the Department of Mathematics; one reading room in the Department of Architecture; and two reading rooms in dormitory areas.

Included in the central collection are general reference books and periodicals, works in agriculture, biology, education and psychology, economics and business, the humanities, the natural and social sciences, maps, manuscripts, and government documents. Among special collections are the Penn State Collection, a Joseph Priestley and a John O'Hara Collection, labor history archives, Audio Archives Collection, Australiana and Utopian literature, the Allison-Shelley Collection of Anglica Americana Germanica, music cassettes, microforms, and a rare book collection. Housed in Pattee Library is the Penntap Information System, which serves industries, municipalities, and businesses in the Commonwealth. In the reading room and special branch libraries are books and journals needed for work assigned in the Colleges mentioned above. A library handbook for students is available at the Information Desk on the main floor of Pattee. As a part of regularly scheduled University courses, instruction in the use of library resources will be provided, upon request, by library faculty. General library orientation tours are offered at the beginning of each term. Computerized literature searches of selected data bases in engineering, earth and mineral sciences, and in the physical, social, and life sciences are available through the General Reference Section and the related branch libraries.

The University Libraries are a member of numerous cooperative groups. They are one of the four Regional Library Resource Centers as established by Pennsylvania law and have memberships in the Union Library Catalogue of Pennsylvania, the Association of Research Libraries, the Mid-Atlantic Research Libraries Information Network, the Area College Library Cooperative Program of Central Pennsylvania, and the Pittsburgh Regional Library Center.

The libraries have approximately 2,010,000 catalogued volumes, 900,000 government documents, 32,900 serials, 204,000 maps, 35,000 pamphlets, 1,900,000 microforms, 2,240 music cassettes, and about 1,900,000 other bibliographical items. Among the special resource guides issued by the library are *Newspapers in Microform*, *Pennsylvania Maps and Atlases*, *Serial Holdings in The Pennsylvania State University Libraries at University Park*, and *Guide to Sources in Black Studies in The Pennsylvania State University Libraries*. The library also issues *Voices and Events*, a catalogue of audio tapes recorded on the University Park Campus.

COMPUTATION CENTER

The Computation Center aids in the education and research programs of all academic departments. Its facilities are open to graduate students and faculty engaged in research and to students doing class assignments. Its equipment includes a large IBM computer, an ADAGE AGT-30, a 1401, and several

peripheral machines. The System/370 Model 168 has four million bytes of main storage, one billion bytes of disk storage, and a large configuration of input/output equipment. Access to the Model 168 can be obtained through high-speed batch terminals located on the main campus. Several access stations providing instant turnaround for short jobs are available for students first learning to use the computer. Typewriter terminals may access either the APL/360 time-sharing system or a Remote Job Entry facility using the dial telephone network. A large ADAGE AGT-30 Computer Graphics System allows extensive computer graphics work. An interface to the Model 168 further extends its graphics capability.

The Computation Center staff conducts workshops to acquaint graduate students and faculty with its services. Students who will need the center's facilities should attend these workshops and consult the staff early in their research so that programs can be worked out for their projects and work scheduled without delay. Programming consultants in the center provide advice and assistance in using library programs prepared by the center and in programming and checking out new applications. The facilities of the Computation Center are widely used for instruction and research in most academic departments at no charge to the student. The Milton S. Hershey Medical Center, the Capitol Campus, the King of Prussia Graduate Center, and Behrend College have remote batch terminals which permit processing of computer jobs at the central computer equipment operated by the Computation Center at University Park.

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus and within comfortable walking distance of most of the campus, provide one- and two-bedroom apartments for graduate students with families.

The Eastview Terrace apartments are fire-resistant, steel-framework, one-story buildings. There are forty-six one-bedroom units (\$115 per month) and thirty-two two-bedroom units (\$125 per month). Rent includes utilities except for electricity, telephone, and TV cable. Water is heated electrically. The units are unfurnished except for electric stove and refrigerator. For each two units, there is a utility room with two stationary laundry tubs and storage space. Privately owned automatic washers may be installed in apartment kitchens only. No coin-operated facilities are available.

Graduate Circle has 144 one-bedroom apartments (\$120 per month) and 72 two-bedroom apartments (\$130 per month) in sixteen two-story buildings of brick and frame construction. Rent includes all utilities except for telephone and TV cable. Each kitchen has a double stainless steel sink with disposal unit, a gas stove, kitchen cabinets, and an electric refrigerator. One bedroom has a built-in chest of drawers; otherwise, the units are unfurnished. There are no facilities for private washing machines in the apartments; however, coin-operated laundries at nominal fees are provided in five of the buildings throughout the area. A basement storage locker is provided for each apartment.

Residence in Graduate Circle or Eastview Terrace Graduate Family Apartments is limited to registered full-time graduate students who are candidates for advanced degrees. All students must live with their spouse and/or preschool children in the apartment. Families with children of school age (including kindergarten) or with children who will come of school age during the term of the lease cannot be considered for occupancy. The one-bedroom units are designed for a graduate student and spouse, and the two-bedroom units for a family with not more than two children.

Atherton Hall, located near the Hetzel Union Building, and McKee Hall, located near the Kern Graduate Building, are residence halls which provide combined room and board accommodations for single graduate men and women. Most assignments are made to double rooms since single rooms are available for only one out of three students. Rates for room and board for these halls can be obtained from the Assignment Office. For additional information on living accommodations, contact the Assignment Office for Campus Residences, 101 Shields Building, University Park, PA 16802. Telephone: (814) 865-7501.

All rates are subject to change by action of the University.

Information on other living accommodations available in the community may be obtained through:

STUDENT SERVICES

The Graduate Student Association
305 Kern Graduate Building
The Pennsylvania State University
University Park, Pennsylvania 16802
Phone: (814) 865-9061

The Organization of Town Independent Students
20 Hetzel Union Building
The Pennsylvania State University
University Park, Pennsylvania 16802
Phone: (814) 865-6851

The State College Area Chamber of Commerce
131 Sowers Street
State College, Pennsylvania 16801
Phone: (814) 237-7644

Graduate students should arrange for their accommodations well in advance of the beginning of classes, because it may be very difficult to find convenient housing at the last minute. **STUDENTS MUST BE ADMITTED TO THE GRADUATE SCHOOL BEFORE THEIR REQUESTS FOR ON-CAMPUS LIVING ACCOMMODATIONS CAN BE PROCESSED.**

STUDENT SERVICES

The facilities and services outlined in the following paragraphs are available to graduate students.

UNIVERSITY HEALTH SERVICES

Located in the central campus area, the Ritenour Health Center is the core of the health service activities and is composed of a dispensary and a hospital. Its facilities are available to full-time graduate students qualifying for nonacademic student benefits and privileges; that is, students registered for 6 or more credits or the equivalent (students holding quarter-time, half-time, or three-quarter-time assistantships.)* The outpatient dispensary handles student medical problems from 8:00 a.m. until 4:45 p.m. daily except Saturdays, when hours are from 8:00 a.m. to 11:45 a.m. During other periods, including Sundays and holidays, patients are seen for emergencies only in the Emergency Room of the University Hospital, which is part of the Health Center complex. There is a \$5.00 emergency charge per visit.

The University Hospital is well equipped to handle the more serious illnesses and injuries on an inpatient basis. A twenty-five-bed facility, it is staffed with professional personnel twenty-four hours a day during the school terms. Should the need arise for special medical or surgical treatment — major surgery, for example — the student will be transferred to a personally chosen hospital facility.

Included in the Health Center facilities are a dental office for emergency dental care, a physiotherapy department, and a pharmacy.

Hospitalized students will be charged \$25 per day during confinement, and a nominal charge will be made for X-rays and all drugs dispensed to hospital or dispensary patients. Consultation with or treatment by physicians other than the professional staff at the Health Center is at the student's expense. All accounts should be settled before the end of the term in which charges were incurred.

The Ritenour Health Center maintains an ambulance service for local transportation of students with nonambulatory illnesses and injuries.

HEALTH INSURANCE

Comprehensive, low-cost medical insurance is available for full- and part-time graduate students and

*Eligibility is determined by the Graduate School when the I.D. cards are issued.

their dependents. Information concerning the specifics of the policy can be obtained by contacting the Graduate Student Association, 305 Kern Graduate Building, University Park, PA 16802 (Tel. 865-4211).

MEDICAID BENEFITS

Graduate students may qualify for most of the benefits that apply to hospitalization and medical treatment under Medicaid. Graduate students who are permanent residents of Centre County may apply for state medical assistance to the Office of the Centre County Board of Assistance, Bellefonte, PA 16823 (Tel. 355-5531).

HEALTH SERVICES FOR CHILDREN

Many medical services are available for children under twenty-one through the State Health Center. The services range from simple immunizations to complicated surgery. Diagnostic study and consultation at the center are made regardless of the ability to pay; however, not all services are free. Children may be referred to the center by physicians or health and welfare agencies. Any preschool child is eligible for free well-child examinations and immunizations. Since many of the services require continual consultation with the physician, referrals must be by physicians located in Centre County. For additional information, consult your doctor, or contact the Health Center at 110 South School Street, Bellefonte, PA 16823 (Tel. 355-5438).

INSURANCE PROTECTION

The Pennsylvania State University is an instrumentality of the Commonwealth performing its function of education. It is not liable for the negligence of its officers, servants, and employees when in the exercise of public or governmental powers or in the performance of public or governmental duties incident to the general education work of the University.

Therefore, any student who desires insurance protection while in attendance at the University against (1) personal injury and/or (2) loss of property by fire or theft should arrange personally for whatever insurance seems advisable.

CAREER DEVELOPMENT AND PLACEMENT CENTER

The center functions as both a counseling and placement service for students. Its primary purpose is to serve students, both individually and in groups, by assisting them through career and educational counseling in formulating immediate and long-range career plans.

The center cooperates with the colleges and departments of the University to assist students in implementing career plans upon graduation. Services include: (1) a library containing information on career opportunities, employer characteristics, and graduate and professional schools; (2) scheduled interviews with prospective employers who are visiting the campus; (3) a file of employment opportunities for which a student may apply by mail; (4) a listing of career-related summer jobs and internships; (5) workshops in interviewing skills and techniques; (6) a variety of informational meetings and publications; and (7) credential services for candidates seeking positions in educational institutions.

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

University Park Campus and Medical Center (Nonmedical Students) — 8 or more credits, total charge of \$484 for Pennsylvanians and \$944 for non-Pennsylvanians; 7 or fewer credits, \$60 per credit for Pennsylvanians and \$118 for non-Pennsylvanians. These rates apply also to off-campus research and other approved individual study.

TUITION AND CHARGES

Behrend College, King of Prussia Graduate Center, and Capitol Campus — 8 or more credits, total charge of \$411 for Pennsylvanians and \$944 for non-Pennsylvanians; 7 or fewer credits, \$47 per credit at Behrend, \$51 per credit at King of Prussia and Capitol, for Pennsylvanians; \$118 per credit at all locations for non-Pennsylvanians.

Continuing Education Center — Tuition for continuing education courses carrying graduate credit will be charged at the prevailing rate at the campus where the courses are offered.

Vocational Education Program — 8 or more credits, total charge of \$484 for Pennsylvanians and \$944 for non-Pennsylvanians; 7 or fewer credits, \$60 per total program for Pennsylvanians and \$118 for non-Pennsylvanians (vocational education courses are indicated by "v" following the course number).

Tuition is the same for courses whether audited or taken for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of \$25. A student whose account is delinquent for more than ten days is subject to suspension from the University.

When it appears that an applicant for admission is not domiciled in Pennsylvania, a non-Pennsylvanian classification is assigned. If the student who is thus admitted believes that circumstances do not justify classification as a non-Pennsylvanian, a petition can be made to the Financial Officer for the Dean of the Graduate School, 316 Kern Graduate Building, University Park, PA 16802, for reclassification. (See Student Pennsylvania Resident Status, page 61.)

All tuition costs may be subject to change.

TUITION REFUND POLICY

Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the Office of Graduate Student Programs and presents it, together with a current Certificate of Registration, at the Office of the Fee Assessor no later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term, in accordance with the following schedule:

Refund of 80 percent upon withdrawal before the end of the first week of the term (seventh consecutive calendar day from the first day of classes) and a decrease of 20 percent for each week thereafter, up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIFIC CHARGES

In addition to the foregoing tuition and charges, the following charges apply under special conditions and are to be paid independently:

Application fee	\$20.00
Change of schedule, each change	2.00
Duplicate meal ticket	2.00
Duplicate student identification and activity card	each 5.00
Music, individual lessons	30.00 to 100.00
Privilege of late payment	25.00
Privilege of late registration	10.00
Special Ph.D. thesis preparation registration fee (601, 611)	118.00
Student parking fee, each term	10.00
Teacher placement service registration fee	10.00
Teacher placement service reactivation fee	10.00
Thesis microfilming and binding fee for master's candidate (one copy)	12.50
Thesis microfilming and binding fee for doctoral candidate (one copy)	40.00
Transcript of records (with seal), each copy	2.00
Mailing diploma in absentia	5.00

A student's transcript, diploma, or both, may be withheld until any outstanding financial obligations to the University have been paid.

MOTOR VEHICLE CHARGES

Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) while at the University is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no registration charge for students who do not desire campus driving or parking privileges. Failure to register a vehicle renders a student liable for a fine of \$15 for each offense or a magistrate's citation.

A permit allowing limited driving and parking on the campus throughout the week costs \$10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only \$3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles. A graduate assistant receiving no fee decals must present the owner's card for the vehicle each term. Pennsylvania registration of all motor vehicles is required if the student lives for more than thirty consecutive days of the year in Pennsylvania. A student's spouse may be required to register his or her car in Pennsylvania. A *Student Parking and Traffic Regulations* booklet is available in Room 209, Hetzel Union Building.

Bicycles — A bicycle is defined as a two-wheeled vehicle propelled by human power. All bicycles operated on the University Park Campus or in the surrounding community must be registered once each year. Expiration date is May 31. Registration may be obtained at the Department of University Safety, 12 Grange Building, Monday through Friday between 8:00 a.m. and 5:00 p.m. Rules and regulations are available at the time of registration.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if acceptance is indicated before April 15, will have complete freedom through April 15 to submit in writing a resignation of the appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits the student to not accept another appointment without first obtaining a formal release.

Selection of recipients of all University awards is made without regard to the sex, race, religious belief, or ethnic origin or handicap or age of the applicant, as provided by law.

ASSISTANTSHIPS

Approximately 2,200 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some major programs. An appointee may serve as an assistant in classroom or laboratory instruction, in research, or in other work.

A prospective student should write directly to the person in charge of the intended graduate major program for information and application forms. Appointments are made subject to the student's admission to the Graduate School as a degree candidate. Clear evidence of superior ability and promise is required. Reappointment to an assistantship is based on availability of positions and the quality of the student's work. In most departments or major programs the number of appointment renewals is limited. A common policy is to limit eligibility to two calendar years of study for a master's candidate or five total years for a doctoral candidate.

The assistantships vary as follows:

QUARTER-TIME—The student normally schedules 7-9 credits per term, receives a stipend in the range \$174-264 per month plus a grant-in-aid of tuition, and is assigned tasks requiring a maximum of 120 hours per term (e.g., ten hours of effort per week for twelve weeks).

HALF-TIME—The student normally schedules 5-7 credits per term, receives a stipend in the range \$348-528 per month plus a grant-in-aid of tuition, and is assigned tasks requiring a maximum of 240 hours per term (e.g., twenty hours of effort per week for twelve weeks).

THREE-QUARTER-TIME—The student normally schedules 4-5 credits per term, receives a stipend in the range \$522-792 per month plus a grant-in-aid of tuition, and is assigned tasks requiring a maximum of 360 hours per term (e.g., thirty hours of effort per week for twelve weeks).

The credit load limits specified above may be increased or decreased for a specific term by permission of the assistantship supervisor, provided the total work load is properly balanced in each term and the total credit load over a series of terms is in conformity with the specified limits stated above. Work assigned as a part of assistantship duties for which academic credit is granted need not be counted as a part of the credit limits stated above.

In addition to receiving a grant-in-aid to cover tuition during the term of appointment, a graduate assistant completing three or more consecutive terms of appointment is entitled to apply for an extra earned grant-in-aid to cover tuition for the succeeding term if a scholarship or fellowship is not received from another source during the term. To receive this privilege a student must obtain an Earned Extra Grant-in-Aid Form from the head of the department or program in which the assistantship was held and must follow the instructions on the form in making application.

A graduate assistant may accept concurrent employment outside the University only with permission from the assistantship department head and the assistant's graduate academic program chairman. Concurrent employment normally may not be held with the University. A student may receive a concurrent fellowship supplement.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS AND TRAINEESHIPS

About three hundred fellowships and traineeships are awarded annually. Recipients must be superior students and are sometimes required to have completed a certain minimum of graduate work before being eligible for an award. Need is also frequently a consideration. Fellows and trainees are required to carry 8-10 credits of course work each term or the equivalent in research, receive stipends which vary with the awards, and normally receive grants-in-aid of tuition paid by the donors of the awards. They may not accept employment during the terms of their appointments (except with special permission for training purposes) nor are they required to render any service to the University. In some cases a recipient will be expected to engage in research in a broad field specified by the donor. There is no sharp distinction between a fellowship and a traineeship. Scholarly excellence is always a major consideration and usually the most important criterion in selecting fellowship recipients. Other considerations commonly come first in awarding traineeships.

GRADUATE SCHOOL FELLOWSHIPS — A number of fellowships, each paying a stipend of up to \$448/month and providing a grant-in-aid to cover tuition charges, are given by the University and are designated as Graduate School Fellowships. They are available to outstanding graduate students working toward a Ph.D., D.Ed., or M.F.A. degree. The ability of applicants being comparable, some preference is given to students majoring in the humanities and social sciences.

Application forms may be obtained from the Graduate School Fellowship Office, 320 Kern Graduate Building. Applications must be submitted through the applicant's graduate major program and must be received by the Graduate School by the first Monday in February to be considered for the following year. Graduate Record Examination verbal, quantitative, and analytical test scores are required of all applicants.

ERIC A. WALKER AND SPECIAL GRADUATE SCHOOL FELLOWSHIPS, FELLOWSHIP SUPPLEMENTS, AND GRANTS-IN-AID — These are open only to students who have been approved for admission but are not yet enrolled in the Graduate School at the time of application. Full fellowships pay up to \$424/month plus tuition. Grants-in-aid provide only tuition. Supplements are small grants in addition to a graduate assistantship or another fellowship. Some supplements are in the

form of low-interest loans: Application forms may be obtained from the Fellowship Office, 320 Kern Graduate Building, University Park, PA 16802, and must be submitted through the person in charge of the applicant's graduate major program so as to reach the Graduate School by mid-February to be considered for the following fall. Applicants must arrange to have Graduate Record Examination verbal, quantitative, and analytical test scores sent to the Graduate School by the application deadline.

MINORITY GRADUATE SCHOLARS AWARDS — These are fellowships, assistantships, and fellowship supplements granted as a part of the University's comprehensive educational opportunity program. Stipends and qualifications are the same as for other fellowships and assistantships. For further information contact the Graduate School Fellowship Office, 320 Kern Graduate Building.

FELLOWSHIPS AND TRAINEESHIPS FROM SPECIFIC GRANTS TO DEPARTMENTS AND DIVISIONS BY FOUNDATIONS, INDUSTRIAL CONCERNS, AND FEDERAL AGENCIES — Over 200 such awards, with various stipends, are granted through individual departments and state and national organizations. Information and application forms may be secured from the person in charge of the appropriate graduate major program. The specific awards will vary somewhat from year to year, but the following are typical of those which were available for 1977-78.

ADMINISTRATION ON AGING TRAINEESHIPS — Available to graduate students admitted for study in selected programs; stipend varies. Details available from the Gerontology Center, S-211 Henderson Human Development Building.

AMELIA EARHART FELLOWSHIP — Available to a woman graduate student in Aerospace Engineering; stipend \$3,000.

AMERICAN CHEMICAL SOCIETY FELLOWSHIPS (2) — Open to graduate students in Geochemistry, Mineralogy, and Solid State Science; stipend \$2,400.

CONTINENTAL OIL COMPANY FELLOWSHIP — Available to a graduate student in Petroleum and Natural Gas Engineering for studies in petroleum engineering; stipend \$2,280.

CONTINENTAL OIL COMPANY FELLOWSHIP IN PETROLEUM ECONOMICS — Available to a graduate student in Mineral Economics for studies in petroleum economics; stipend \$2,280.

DOLOMITE BRICK CORPORATION GRADUATE FELLOWSHIP — Available to a graduate student in ceramic science and engineering for research on the thermal/mechanical behavior of dolomite refractories; stipend \$4,000 plus tuition.

DU PONT FELLOWSHIP — Available to a graduate student in Mechanical Engineering; stipend \$4,200 per year (four terms) plus tuition. In addition a \$1,000 fund is available for student research activity.

W. S. ELLIOTT FELLOWSHIP — Available to a graduate student who is a graduate of The Pennsylvania State University and is interested in engineering research; stipend \$1,200.

ERNST AND ERNST FELLOWSHIP — Available to a master's candidate in accounting; stipend \$1,000.

F.I.R.E. — Research in field of thermal/mechanical behavior of refractories. Available to a student in Ceramic Science; stipend \$3,600 per year.

HERMAN G. FISHER GRADUATE FELLOWSHIP — Available to an advanced graduate student in Human Development and Family Studies and especially interested in work with young children; stipend \$3,500 for tuition and other expenses.

GENERAL FOODS FUND FELLOWSHIPS (2) — Open to graduate students with a major in the College of Human Development or in Home Economics Education; stipend for doctoral \$3,000, for master's \$2,000 for tuition and other expenses.

GULF OIL COMPANY FELLOWSHIP IN CHEMICAL ENGINEERING — Available to a U.S. citizen who is a graduate student in Chemical Engineering; stipend \$3,636.

GULF OIL COMPANY FELLOWSHIP IN PETROLEUM AND NATURAL GAS ENGINEERING — Available to a graduate student for work in petroleum production; stipend \$2,400.

JAMES HAMILTON HARTZELL AND LUCRETIA IRVINE BOYD HARTZELL HISTORY AWARD — Available to graduate students in History whose field of interest is Pennsylvania history; stipend variable.

HASKINS AND SELLS FOUNDATION FELLOWSHIP — Available to a graduate student in accounting; stipend \$2,500.

WALTER E. HELLER FELLOWSHIP — Provided by Walter E. Heller & Company, in the amount of \$1,000 for a candidate for the degree of Master of Business Administration.

HILL FELLOWSHIPS FOR STUDY IN ANTHROPOLOGY OR HISTORY — Details available from Dean S.F. Paulson of the College of the Liberal Arts, 108 Sparks Building.

H. R. IMBT SERVICES, INC. FELLOWSHIP — For graduate work in Civil Engineering in the field of civil engineering construction; stipend \$3,000.

- INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION FELLOWSHIP** — In support of research on the application of lead and zinc compounds to chemical, ceramic, electrical, and allied industries. Available to students in Ceramic Science; stipend \$3,000.
- INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION FELLOWSHIP** — In support of research on the physics and chemistry of lead and zinc compounds. Available to a student in Solid State Science; stipend \$2,540.
- JOSEPH M. JOHNSTON MEMORIAL SCHOLARSHIP** — Available to a student whose program is related to floriculture; stipend variable. Apply through the Department of Horticulture.
- SAMUEL H. KRESS FOUNDATION** — Makes available travel grants and research stipends for American students in art history, architecture, and conservation; for doctoral candidates only.
- NATIONAL INSTITUTE OF AGING TRAINEESHIPS** — Available to doctoral students in selected graduate programs for research training in adult development and aging; stipend varies. Details available from the Gerontology Center, S-211 Henderson Human Development Building.
- NATIONAL STEEL CORPORATION FELLOWSHIP** — Available to a graduate student in Metallurgy; stipend \$4,848.
- MRS. A. ROBERT NOLL GRADUATE FELLOWSHIP IN APPLIED PHYSIOLOGY** — For graduate research in applied physiology; especially in environmental or exercise physiology; stipend variable.
- NORTON COMPANY FELLOWSHIP** — Available to a graduate student in Ceramic Science for research on thermal/mechanical properties; stipend \$3,600.
- EDWARD ORTON, JR., CERAMIC FOUNDATION FELLOWSHIPS** — For graduate research in Ceramic Science, especially in regard to the firing behavior of classical ceramic compositions; stipend \$4,800 (variable).
- OWENS-ILLINOIS FELLOWSHIP** — Available to a graduate student in Ceramic Science whose thesis is in the area of glass science and technology; stipend \$3,000-3,600.
- P.P.&L. POWER PLANT CONSTRUCTION MANAGEMENT GRANT** — Available to a graduate student in Civil Engineering to support a portion of the study phase of a student's graduate work study program with P.P.&L; stipend \$2,500.
- PENNSYLVANIA COOPERATIVE FISHERY UNIT FELLOWSHIPS (3-4)** — Open to graduate students in zoology; stipend \$2,400-2,460.
- PENNSYLVANIA MEAT PACKERS' ASSOCIATION SCHOLARSHIP** — Open to a selected graduate student specializing in meat science; stipend \$600. Apply through the Department of Dairy and Animal Science.
- PRICE WATERHOUSE FOUNDATION FELLOWSHIP** — Available to a Ph.D. candidate in accounting; stipend variable up to \$5,000.
- RCA CORPORATION FELLOWSHIP** — Available to a graduate student in Electrical Engineering; stipend \$2,500-3,000 for nine months. May be supplemented for an additional three months on application.
- ST. JOE MINERAL CORPORATION FELLOWSHIP** — Available to a graduate student in Metallurgy; stipend \$4,608.
- SHAEFFER SCHOLARS PROGRAM** — Provided by Charles W. Shaeffer ('33), retired board chairman, T. Rowe Price Associates, to M.B.A. candidates evidencing strong academic and managerial potential; stipend \$4,000. Apply to director of M.B.A. program.
- EDWIN ERLE SPARKS DISSERTATION FELLOWSHIP IN THE HUMANITIES** — Available to a doctoral candidate in one of the following graduate programs: Classics, Comparative Literature, English, French, German, History, Linguistics, Philosophy, Religious Studies, Slavic Languages and Literatures, Spanish, and Speech Communication; stipend \$3,500 plus tuition. Apply to relevant department or program before February 1.
- EDWIN ERLE SPARKS FELLOWSHIPS IN THE HUMANITIES (8)** — Available to beginning graduate students in one of the following graduate programs: Classics, Comparative Literature, English, French, German, History, Linguistics, Philosophy, Religious Studies, Slavic Languages and Literatures, Spanish, and Speech Communication; stipends \$2,600 plus tuition. Apply to relevant department or program before February 1.
- TEXACO FELLOWSHIP IN EARTH AND MINERAL SCIENCES** — Available to a graduate student in the College of Earth and Mineral Sciences; stipend \$1,200-3,000 plus tuition.
- TEXACO FELLOWSHIP IN ENVIRONMENTAL STUDIES** — Available to a graduate student majoring in engineering with environmental emphasis through the Center for Air Environment Studies, 226 Fenske Lab; stipend \$3,000 per year plus tuition.
- WALTER THOMAS MEMORIAL SCHOLARSHIP** — Available to a student studying the nutrition of horticultural crops; stipend variable. Apply through the Department of Horticulture.

- UNION CARBIDE FELLOWSHIP** — Available to a graduate student in Mechanical Engineering; stipend \$4,200 per year (four terms) plus tuition. In addition a \$1,000 fund is available for student research activity.
- U.S. OFFICE OF EDUCATION BILINGUAL EDUCATION FELLOWSHIPS** — Available to Ph.D. and D.Ed. candidates preparing for professional careers in bilingual education or a related field; stipend \$3,000-4,700 plus dependency allowance, tuition, books, and fees. Apply to Director, Bilingual Education Program, Division of Curriculum and Instruction, College of Education.
- U.S. OFFICE OF EDUCATION FELLOWSHIPS IN SPEECH PATHOLOGY AND AUDIOLOGY: WORK WITH THE SPEECH-HANDICAPPED; WORK WITH THE DEAF** — Open to graduate students specializing in these fields; stipend up to \$1,200-2,400 plus dependency allowance. Apply to the Director of the Speech and Hearing Clinic.
- U.S. OFFICE OF EDUCATION PUBLIC SERVICE FELLOWSHIPS** — Available through the Institute of Public Administration; a stipend of \$3,000 for twelve months, an allowance of \$500 for each dependent, and tuition. Fellowships are awarded only to students in the Master of Public Administration degree program.
- U.S. OFFICE OF EDUCATION TRAINEESHIPS IN APPLIED INTERDISCIPLINARY RESEARCH: EARLY CHILDHOOD INTERVENTION** — Available for advanced graduate students preparing for careers in research with the young handicapped child; stipend \$2,600-3,200 plus tuition and dependency allowance. Apply to Graduate Program in Human Development and Family Studies.
- U.S. OFFICE OF EDUCATION TRAINEESHIPS IN EDUCATION OF EXCEPTIONAL CHILDREN (28)** — Open to graduate students being prepared as leadership personnel in the education of handicapped children; stipend \$300-600 per term plus tuition. Graduate assistantships also available. Apply to the Graduate Admissions Committee, 307 CEDAR Building.
- U.S. OFFICE OF EDUCATION VOCATIONAL EDUCATION GRADUATE LEADERSHIP DEVELOPMENT FELLOWSHIPS** — Available to qualified, experienced vocational educators to spend full time in advanced study of vocational education. Awards are granted for a period not to exceed 36 months; stipend \$5,400 annually plus tuition and an allowance of \$845 per dependent. Details available from Director of Occupational and Vocational Studies, College of Education, 119 Rackley Building.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS** — Available through the Departments of Anthropology, Biological Health, and Man-Environment Relations, and through the Graduate Program in Biophysics of the Department of Biochemistry and Biophysics; stipend \$3,900.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN CLINICAL PSYCHOLOGY (14)** — Available through the Department of Psychology; stipend \$2,925 for nine months plus tuition.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN NURSING** — Open to selected registered nurse students in nursing; stipend \$3,900 plus tuition and dependency allowance. Apply to Professor in Charge, Graduate Program in Nursing.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN RESEARCH ON LIFE SPAN DEVELOPMENT AND THE FAMILY** — Open to selected post-master's graduate students in Human Development and Family Studies who are interested in research on the mental health aspects of individual and family development; stipend \$3,900. Apply to Graduate Program in Human Development and Family Studies.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN SOCIAL GERONTOLOGY (12)** — Open to selected post-master's graduate students in the social and behavioral sciences; stipend \$2,600-2,800 plus dependency allowance. Apply to Director, Program in Adult Development and Aging, S-110 Henderson Human Development Building.
- U.S. REHABILITATION SERVICES ADMINISTRATION TRAINEESHIPS IN SPEECH PATHOLOGY AND AUDIOLOGY (7)** — Open to graduate students specializing in speech pathology and audiology and hearing impaired; stipend \$2,400-4,100.
- U.S. REHABILITATION SERVICES ADMINISTRATION TRAINEESHIPS IN THERAPEUTIC RECREATION (6)** — Open to graduate students specializing in therapeutic recreation; stipend \$1,800 (three terms). Apply through the Graduate Program in Recreation and Parks.
- U.S. VOCATIONAL REHABILITATION ADMINISTRATION TRAINEESHIPS IN VOCATIONAL REHABILITATION COUNSELING (36)** — Open to graduate students in Counselor Education who are specializing in vocational rehabilitation counseling; stipend \$1,800-2,000.
- VETERANS ADMINISTRATION INTERNSHIPS IN CLINICAL PSYCHOLOGY** — A limited number of internships in veterans administration agencies (hospitals and clinics) are available to graduate students in clinical psychology upon direct application to the agency's chief psychologist with endorsement by the Department of Psychology. Stipend variable.

ARTHUR YOUNG AND COMPANY FELLOWSHIP — Open to a master's degree candidate in accounting from a predominantly black college. Contact the department in the College of Business Administration.

In addition, grants are available from governmental agencies, industrial concerns, foundations, and the armed forces for graduate study and frequently for support of investigations of particular problems. Some of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from the department of specific interest.

EXTERNALLY SPONSORED FELLOWSHIP AND TRAINEESHIP PROGRAMS — Attention is directed to the following national programs, involving numerous fields of study, with which the University cooperates by providing local administration. (See Statement of Nondiscrimination, page 59.)

FEDERAL HIGHWAY ADMINISTRATION FELLOWSHIPS — Provided by the Federal Highway Administration, U.S. Department of Transportation, to develop the expert manpower needed to carry out state and local jurisdiction highway programs. Open to qualified students for graduate study in traffic engineering and other highway-related areas. Only U.S. citizens are eligible. Fellowships are granted for an academic year at \$5,000 each for tuition, books, and living stipends. Application forms are available from the National Highway Institute, U.S. Department of Transportation, Washington, D.C. 20590.

INTERNATIONAL UNIVERSITY FELLOWSHIPS IN SPACE SCIENCE — These graduate and postdoctoral fellowships are available to foreign nationals who hold the equivalent of Master of Science or Master of Engineering degrees and meet graduate student entrance requirements at United States universities. Details on the program will be found in the brochure concerning these fellowships issued by the Office of Scientific Personnel, National Academy of Sciences, Washington, D.C. 20418.

NATIONAL DEFENSE MODERN FOREIGN LANGUAGE FELLOWSHIPS — Under Title VI of the National Defense Education Act of 1958, as amended, the U.S. Commissioner of Education allocates to institutions which have approved programs of study in certain languages of critical importance to the United States, and in the cultural areas related to these languages, graduate fellowships for the study of these languages and the related areas.

Applicants must give reasonable assurance that they will be available after graduate study for teaching a modern foreign language or a related study in a college in the United States or for such other public service as may be specified in the application materials.

In 1977-78 the University awarded three fellowships. Students are eligible who are majoring in Slavic Languages or who are using a Slavic language in their thesis research. For further information contact the Graduate School Fellowship Office, 320 Kern Graduate Building.

NATIONAL SCIENCE FOUNDATION ENERGY-RELATED AND NATIONAL NEEDS GRADUATE TRAINEESHIPS — The Graduate School administers a program of awards to students preparing for careers and conducting research related to coal, oil shale, and alternate energy sources including nuclear and geothermal energy, and the effects of energy production on the environment. Applicants must be degree candidates in certain approved graduate majors. Stipends are \$300 per month. Application forms may be obtained by writing to the Graduate School Fellowship Office, 320 Kern Graduate Building, University Park, PA 16802. The application deadline and procedure are the same as for Graduate School Fellowships.

NATIONAL SCIENCE FOUNDATION FACULTY FELLOWSHIPS — The Graduate School coordinates a program of awards to young college and university teachers (U.S. citizens only) wishing further training or research experience. Awards are made for all or part of a year or for a succession of summer terms. Stipends are related to current academic salary. Application materials may be obtained from the National Science Foundation, Washington, D.C. 20550. The application deadline for 1978 was December 16, 1977.

NATIONAL SCIENCE FOUNDATION GRADUATE FELLOWSHIPS — The Graduate School cooperates in this program of prestige fellowships requiring outstanding credentials. These fellowships are available in the biological, engineering, mathematical, physical, and social sciences, as well as the history and philosophy of science. Application is made during the fall to the Fellowship Office, National Academy of Sciences, National Research Council, 2101 Constitution Ave., N.W., Washington, D.C. 20418.

which has charge of evaluating applicants for the foundation. The stipend is \$325 per month for three years plus remission of tuition. The application deadline for 1978 was December 1, 1977.

U.S. OFFICE OF EDUCATION MINING AND MINERAL AND MINERAL FUEL CONSERVATION FELLOWSHIPS — Available to individuals in appropriate majors working for M.S. or Ph.D. degrees who are U.S. nationals. Thirty-five fellowships were awarded in 1977. Award is based on need, significance of planned research, and academic promise. Stipend is \$325 per month. Application procedures are the same as for Graduate School Fellowships. Awards may be supplemented by additional support.

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION TRAINEESHIPS — Available to graduate students in approved departments, stipend of \$3,900 for twelve months. Application forms may be obtained from the Fellowship Office, 320 Kern Graduate Building, or from participating departments.

OTHER AIDS

GRADUATE SCHOOL TUITION GRANTS-IN-AID — About forty grants of tuition remission for full-time study are awarded each term. They are available to any graduate degree candidate in the third or later term at the University on criteria of financial need and academic promise. A recipient must carry 8 to 10 credits of graduate work but may accept employment of not more than ten hours per week with the University or another employer. Applications for grants for the winter, spring, and summer terms must be filed by the beginning of the fifth week of the preceding term and by mid-April for the fall term. Application forms may be obtained from the Graduate School Fellowship Office, 320 Kern Graduate Building.

THE RUTH YOUNG BOUCKE GRADUATE FELLOWSHIP — Established from the estate of Ruth Young Boucke, whose husband was for many years a professor of economics, this fellowship is available every other year to an outstanding graduate student on the same basis as the regular Graduate School fellowships, and selection is made by the Graduate School Committee on Fellowships and Awards. The stipend is up to \$400/mo. plus a grant-in-aid of the \$118 thesis preparation fee.

LOAN AND EMPLOYMENT PROGRAMS — Any prospective or current graduate degree candidate may seek aid from loan and employment programs directly through the Office of Student Aid, 135 Boucke Building. By filing a Financial Aid Form (used to assess a student's financial need) with the College Scholarship Service, Box 176, Princeton, NJ 08540, and by filing an Application for Financial Aid and a Previous Aid Form with the Office of Student Aid, a prospective graduate student will be considered for the following aid programs:

THE NATIONAL DIRECT STUDENT LOAN PROGRAM is a low-interest loan available to United States citizens and permanent residents with a documented financial need, as determined from the Financial Aid Form. Repayment is not necessary until after graduation or termination of graduate work. A schedule of payments will be arranged at that time. Interest begins to accrue nine months after graduation or termination at the rate of 3 percent per year simple interest. Minimum loan for one year is \$2,500.

UNIVERSITY LOANS are funds established by University organizations, alumni, faculty, staff, and friends to help students who have a documented financial need. The borrower is not expected to repay until after graduation or termination of study. Interest begins to accrue immediately upon graduation or termination of study at a 6 percent per year simple interest rate. Maximum loan for one year is \$2,000.

THE COLLEGE WORK-STUDY PROGRAM is a form of federal aid awarded to a student with a documented financial need who wishes to earn a portion of his or her aid eligibility through part-time employment. Unlike a loan, there is no repayment, because the student is paid an hourly wage for on-campus employment. Earnings may not exceed the documented need determined for the applicant. For the graduate student with an assistantship agreement, this type of aid is not recommended, since one of the stipulations of the assistantship may prohibit additional employment.

THE GUARANTEED STUDENT LOAN PROGRAM provides low-interest loans (7 percent simple interest per annum) to students enrolled on at least a half-time basis. Most graduate students may seek a Guaranteed Student Loan without filing the Financial Aid Form. The loans are repayable after the student graduates or terminates his or her education. This federal financial aid program is a cooperative effort of

the federal government, state government and/or guarantor agency, a commercial lending institution, and the educational institution.

An application, including the Lender's Report, should be obtained from a lending institution which agrees to participate with the student in this program. If the student's adjusted family income, as computed on the Lender's Report, is less than \$25,000, the graduate student is eligible for up to a \$5,000 loan, with the federal government paying the interest while the student remains in school on at least a half-time basis. In cases where the student's adjusted family income is \$25,000 or more, the student may receive a loan with the interest subsidized by the federal government only if need is established through the Financial Aid Form filed with the College Scholarship Service. A graduate student may borrow up to a total of \$15,000, including any Guaranteed Student Loans received for undergraduate study.

Additional information for prospective graduate students may be obtained from the Office of Student Aid, 135 Boucke Building, University Park, PA 16802. In corresponding with this office, specify that you are a current or prospective graduate student, and if the latter, the term you wish to begin graduate study at the University.

When seeking aid, the prospective student should keep in mind the following:

Cost of Attendance — In determining a student's need, the Office of Student Aid uses the following estimates of expenses for an academic year (three terms) as a basic guide. (Estimates are increased for students with dependents.)

Tuition	\$1,452	(Tuition at Behrend,
Room & Board	1,566	Capitol, and King of
Books	240	Prussia is \$1,233; tuition for non-Pennsylvanians at all locations is \$2,832.)
Miscellaneous	876	
Total Estimated Costs	\$4,134	

Nondegree Students — Financial aid is available for graduate students who are degree candidates only. Nondegree graduate students are not eligible.

Summer Term Financial Aid — Students who wish to apply for financial aid for a summer term must file a separate summer Application for Financial Aid with the Office of Student Aid, even if the student received, or will receive, aid for the fall-winter-spring academic year.

The following loans are available only to students in specific graduate programs.

THE U.S. ENVIRONMENTAL PROTECTION AGENCY SPECIAL AIR POLLUTION LOAN FUND has been established through the University's Center for Air Environment Studies. Recipients must be in the terminal year of their program and pursuing a career in air pollution control. Repayment must be completed within three years of graduation. Interest accrues at an annual rate of 3 percent. If the recipient works for two years following graduation for an air pollution control agency, no repayment is required. Apply through the center.

THE UNITED STATES STEEL FOUNDATION LOAN FUND provides loans for emergencies and to supplement fellowships. Recipients must be U.S. citizens who are enrolled full-time in graduate programs in earth and mineral sciences or engineering. Further information may be obtained from the Graduate School Fellowship Office, 320 Kern Graduate Building.

GIRARD EDU-CHECK PLAN — The University offers to sponsors (including parents) of students the Assured Education Plan, enabling them to pay out of current income, on a monthly basis. University bills for tuition, residence hall room and board, and all other items billed by the University. Life insurance and total and permanent disability insurance are a part of the plan for the sponsor up to the sixty-eighth and sixty-first birthdays, respectively. Payments are handled through the Girard Bank, 1339 Chestnut Street, Philadelphia, PA 19107. Further information and application forms may be obtained from the Office of the University Bursar, 103 Shields Building. Signed agreements should be received well in advance of registration, since it takes at least three weeks for completion of arrangements.

STUDENT EMPLOYMENT — Many students depend upon part-time employment to help meet

their expenses. Students who are thus employed, however, must recognize the time demands of their work schedules and will be required to adjust their academic loads accordingly. The Office of Student Employment, 105 Boucke Building, offers assistance in finding part-time employment in town, as well as on campus. This office also provides assistance in finding summer employment throughout the Commonwealth of Pennsylvania. The Office of Student Aid coordinates the Federal College Work-Study program, described above under Loan and Employment Programs.

The State College Area Chamber of Commerce also gives assistance to students seeking part-time employment. The Chamber of Commerce, local placement services, and the University Office of Personnel maintain files of positions open to spouses of students. Many local residents seek help for babysitting, housework, typing, and other general kinds of employment.

A student holding a fellowship or traineeship may not accept employment of any kind for service without special advance approval. A graduate assistant may accept concurrent employment outside the University only after obtaining permission from the department head and person in charge of the major program. Concurrent appointments with the University other than a Fellowship Supplement normally may not be held.

VETERANS' BENEFITS — The Coordinator of Veterans Affairs has the responsibility of handling all applications for benefits under the various Public Laws. Veterans who intend to enroll at the University should contact the Veterans Outreach Office, 335 Boucke Building, University Park, PA 16802, as far in advance as possible to obtain information and necessary forms. The Outreach Office also provides information on other programs and services unique to veterans.

Under P.L. 89-358, a student is entitled to benefits if registered full time for 8 or more credits, unless the department head certifies that fewer credits constitute a full-time academic load for that student (see Full-Time Academic Status, p. 66).

At each registration, a special veterans (V) card must be submitted to confirm enrollment and academic status. Submission of this card does not generate benefits which are not already certified, but failure to submit the card results in immediate interruption of VA benefits.

Veterans in their first term may defer tuition and room and board fees until their benefit checks begin to arrive.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth here in the *Graduate Degree Programs* catalog and in the *Thesis Information Bulletin*, and for meeting the standards and requirements expressed by these regulations. Copies of the graduate catalog are available from the Graduate Commons Information Desk, 113 Kern Graduate Building; the *Thesis Information Bulletin* can be obtained from the Office of Theses and Publications, 320 Kern Graduate Building. Graduate students are encouraged to contact the Office of Graduate Student Programs, 211 Kern Graduate Building (Tel. 865-1834), for guidance if they have any questions, uncertainties, or difficulties concerning any procedure or regulation of the Graduate School or any procedure or regulation of the University as it may affect them.

STATEMENT OF NONDISCRIMINATION

In the selection of individuals for graduate study, in which the University has partial or complete control of the selection process and administration of the program, the University will not discriminate on the basis of race, creed, color, sex, ethnic origin, or handicap or age as provided by law.

ADMISSION

Each step of the educational process, from admission through graduation, requires continuing review and appropriate approval by University officials. The University, therefore, reserves the right to change the requirements and regulations contained in this bulletin and to determine whether a student has satisfactorily met its requirements for admission or graduation, and to reject any applicant for admission for any reason the University determines to be material to the applicant's qualification to pursue higher education.

An applicant for admission to the Graduate School should understand that graduate work is not a simple extension of an undergraduate program but, rather, demands scholarship of a higher order, and emphasizes research, creativity, and professional competence with a minimum of formal requirements and a maximum of student initiative and responsibility.

Objective — The objective of the Graduate School is to admit a qualified graduate student body up to the limit of the University's resources to provide graduate programs of outstanding quality. In general, a student may begin graduate work in fall, winter, spring, or summer.

Applicants must recognize that staff, facilities, and other resources are limited, so that not all qualified persons can be admitted. The number accepted will vary by program, and from term to term. In some graduate programs all vacancies will have been filled long before the general Graduate School deadline for submitting applications, so that even outstanding students cannot be accepted.

Application — Applicants interested in graduate programs offered at University Park or The Milton S. Hershey Medical Center should apply to University Park. Those interested in programs at the Capitol Campus, the King of Prussia Graduate Center, or Behrend College should apply directly to the appropriate campus. Students are normally expected to begin work at the campus to which they are admitted.

Requirements — For admission to the Graduate School, an applicant must have received from an accredited institution a baccalaureate degree earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. Ordinarily, an entering student must have completed in a satisfactory manner a minimum of course work in designated areas, the specific courses and amount of work depending upon the field of advanced study.

A baccalaureate degree holder with a slight deficiency in undergraduate preparation may be admitted and allowed to schedule a limited number of undergraduate courses to remove the deficiency while proceeding in the graduate program. Courses taken for this purpose do not apply toward the requirements of the advanced degree.

Admission may be granted to applicants whose credentials are not complete at the time of application because the baccalaureate degree has not yet been conferred, grades for the current term are not yet available, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission should, for any reason, be canceled, the student is thereby automatically dropped from the Graduate School.

Admission is granted jointly by the Graduate School and the department or graduate program in which the student plans to study. The establishment of standards by which applicants are admitted is a departmental or program responsibility. Although the Graduate School has no fixed minimum grade-point requirement for admission, an applicant is generally expected to maintain a junior-senior grade-point average of at least 2.50 on The Pennsylvania State University grading scale of A (4) to D (1). Individual programs may establish higher grade-point average requirements and use other criteria to judge candidates for admission. In exceptional cases, departments or major programs may also approve admission by reason of special backgrounds, abilities, and interests. Departmental or program requirements are given in the descriptive statements appearing under the major programs listed in the latter part of this publication.

A student who has been admitted to a program in which the doctorate is offered may begin working toward that degree but has no official status as a doctoral student and no assurance of acceptance as a doctoral candidate until a candidacy examination administered by the major department or committee has been passed.

Forms — Application forms may be obtained from the Office of Graduate Admissions. Applicants may apply for admission to only one program at a time. All academic records, including an explanation of the grading system used, should be submitted, *in duplicate*, to the Office of Graduate Admissions, 201 Kern Graduate Building. These must be received from all institutions by the Graduate School at least one month prior to the opening of the term in which the student plans to begin a graduate program.

Deadlines — The deadline for processing of applications by the Graduate School is one month prior to the beginning of any given term. **GRADUATE MAJOR PROGRAMS MAY REQUIRE EARLIER DEADLINES.** A complete Graduate School admissions file, which is required for processing an application, includes the following items: (1) application form, (2) application fee form, (3) a check or money order in the amount of \$20.00 made payable to The Pennsylvania State University, and (4)

duplicate transcripts from each institution of higher education attended. Supplementary materials and examination scores may be required in individual programs. If the admission file is incomplete a month prior to the beginning of the term for which the student has applied, the materials will be processed for the first term following the completion of the admissions file.

Nondegree — A student who plans to take courses for transfer to another institution or to follow a program of study not leading to an advanced degree at this institution should apply for admission as a nondegree student. The adviser for such a student may be appointed by the department head or program chairman most closely associated with the student's field of interest. The number of nondegree students which can be admitted is limited because preference is given to students in degree programs.

Minority Students — Minority students are encouraged to apply for admission to any of the programs offered in the Graduate School. Information concerning programs and financial aid may be obtained from the chairman of the graduate program or the dean of the college of the student's major interest.

Foreign Students — Foreign students should plan to apply at least six months prior to the beginning of the term in which they intend to begin graduate studies. They must submit certified English translations of all academic records. In addition, all foreign students whose native language is not English must take the TOEFL (Test of English as a Foreign Language) and submit the results of this test with the application for admission. Information about the TOEFL can be obtained by writing to the Educational Testing Service, Box 592, Princeton, N.J. 08540. Foreign students are not admitted as nondegree students unless such admission is requested by a sponsoring agency.

UNDERGRADUATE STUDENTS — A student of The Pennsylvania State University who is within three credits of completing the baccalaureate degree may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade-point average of 3.00). Any senior with a 3.50 grade-point average may be admitted to 500-level courses with the consent of the instructor; other undergraduate students with a B average or better may be admitted to such courses with the consent of the instructor and the associate dean of the Office of Graduate Student Programs.

In certain cases undergraduate students may subsequently apply credits they have earned in 400- and 500-series courses toward an advanced degree at The Pennsylvania State University. Upon admission to the Graduate School, and with the approval of the major field, those credits *relevant* to the graduate program of study which were not used to satisfy undergraduate requirements may be applied toward an advanced degree. The time limitation on the completion of a master's degree program applies to these, as well as to other, credits.

GUESTS OF THE UNIVERSITY — It is the policy of the Graduate School not to permit applicants to work for a second doctoral degree. The President, on recommendation of the dean of the Graduate School, will welcome, as guests, holders of earned doctoral degrees who may be visiting the University Park Campus for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the dean of the Graduate School.

STUDENT PENNSYLVANIA RESIDENT STATUS — When it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that the applicant is a non-Pennsylvanian. If a student who is thus admitted believes that the circumstances do not justify classification as a non-Pennsylvanian, a written petition for reclassification may be filed with the Financial Officer of the Graduate School, 316 Kern Graduate Building, University Park, PA 16802. Capitol Campus students may petition the Capitol Campus Financial Officer.

A copy of the *Policy for Determination of Students' Pennsylvania Resident Status* can be obtained in the Office of the Financial Officer mentioned above. Under the rules of this document, when a written petition for reclassification is made, the petitioner is required to present proof of bona fide domicile within the Commonwealth or such other evidence as is pertinent to a complete review of the student's classification. Upon review, a decision by the highest designated authority at the University shall constitute an exhaustion of administrative remedies.

Any reclassification resulting from a student's challenge shall be effective for tuition purposes as of the date such challenge was filed. A student who changes domicile from Pennsylvania to another state must promptly give written notice to the University.

CLASSIFICATION OF STUDENTS

A graduate student may be admitted either as a degree student or as a nondegree student, depending upon the student's objectives. After admission to one of these categories, any change to the other must be arranged through the Office of Graduate Student Programs.

DEGREE STUDENTS — A degree student is one who plans to become a candidate for an advanced degree at The Pennsylvania State University and who has been formally admitted for advanced studies in a particular program. The program of study is developed under the guidance of an adviser appointed by the head of the student's major program. A degree student who has passed a candidacy examination is classified as a doctoral candidate.

NONDEGREE STUDENTS — An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced degree at this institution, may arrange for a program of work as a nondegree student. This classification includes students who plan to transfer credits to another institution and those who plan special programs of study not leading to an advanced degree. The number of nondegree students who can be admitted is limited, and it is increasingly difficult to provide for them because of the limitation of resources. Preference is given to students in degree programs.

Nondegree students who are applying for admission to the University Park Campus *must* submit two transcripts from each institution attended. Transcripts should be sent to the Office of Graduate Admissions, 201 Kern Graduate Building, The Pennsylvania State University, University Park, PA 16802.

The admission of a nondegree graduate student at the University Park Campus will be subject to the recommendation of the program chairman or head of the department of the student's primary interest and proposed area of work. Casual students with broad interests not easily identifiable with a single program may be admitted directly by the Graduate School. Applications and credentials must be received at least one month prior to the anticipated term of enrollment. A maximum of 12 credits earned as a nondegree student may be applied to a degree program.

UNDERGRADUATE NONDEGREE STUDENTS — Such a student is not a graduate student since a baccalaureate degree has not been earned. The student may not register for graduate courses or research (500 and 600 series) without permission from the Office of Graduate Student Programs. A student having attained junior standing in college may register for 400-level courses and is admitted through undergraduate admissions.

PROGRAMS

MAJOR PROGRAM — A student's major program is the field of primary interest and the one in which the greater portion of graduate work is taken. Programs are designed to prepare students to assume positions of informed and responsible authority in their fields and to contribute creatively to them. They promote not only specialization, but also breadth of scholarship, the ability to study and think independently, and familiarity with the principal techniques and important literature in the field. The research undertaken by the candidate should deal with a problem which represents a significant contribution to knowledge.

SPECIAL INTERDISCIPLINARY MAJORS — In addition to the graduate major programs listed in this bulletin on pages 82-83, special interdisciplinary majors involving two or more departments within a single college, or intercollege majors involving two or more colleges, may be arranged with the approval of the dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental or intercollege committees.

In general, departments of the University are identified with specific major programs. Thus, aerospace engineering is a major program of study which is offered under the supervision of the Department of Aerospace Engineering. On the other hand, acoustics and genetics are major programs for which there are no corresponding departments. In such cases, a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one program. For instance, the Department of Material Sciences offers work in ceramic science, fuel science, metallurgy, and mineral processing.

Applicants for admission are encouraged to consult the person whose name is listed under the major program heading in the Programs and Courses section.

ADVANCED DEGREES OFFERED

The degrees of Doctor of Philosophy and Doctor of Education are conferred by the University. Both require high attainment and productive scholarship, but the Ph.D. places a strong emphasis on research, whereas the D.Ed. emphasizes professional competence in some field of education.

The Master of Arts and the Master of Science degrees are academic in nature, the programs placing strong emphasis on basic knowledge and research. The professional master's degrees conferred are the Master of Administration, Master of Agriculture, Master of Architecture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forest Resources, Master of Music, Master of Psychosocial Science, Master of Public Administration, and Master of Regional Planning.

Candidates for the M.Ad., M.P.A., M.Ps.Sc., or M.R.P. degrees may meet all the requirements for these degrees at the Capitol Campus of The Pennsylvania State University. Programs leading to the degree of Master of Engineering with a major in engineering science have been approved for Behrend College, the King of Prussia Graduate Center, and the Capitol Campus. Designation of location of program completion will be noted on the student's transcript.

CHANGE OF DEGREE OR PROGRAM

A graduate student who has been admitted for work in one major program but wishes to transfer to another should submit a request to the Office of Graduate Student Programs of the Graduate School. The student's credentials will be reviewed and the proposed new major department head or committee chairman consulted. If the change is approved but the student is inadequately prepared for the new major, the student may be required to make up certain undergraduate deficiencies.

A graduate student admitted for either an academic degree (M.A., M.S., or Ph.D.) or a professional degree (M.Ad., M.Agr., M.Arch., M.B.A., M.E.P.C., M.Ed., M.Eng., M.F.A., M.F.R., M.Mus., M.P.A., M.Ps.Sc., M.R.P., or D.Ed.) who wishes to change from one type of degree program to another must apply to the Office of Graduate Student Programs for the transfer. Similarly, a student who has earned a master's degree but wishes to earn a different type of doctoral degree must apply for a formal transfer. A student may be required to make up certain deficiencies if inadequately prepared for the new program.

GRADUATE CREDITS

It is important that the student understand that in the Graduate School the word "credit" has no meaning other than as a unit of time — time spent in residence and in off-campus graduate work. One credit stands for the equivalent of approximately one week of full-time graduate work, and 10 credits for a term's work.

Typically, a candidate for an advanced degree is required to earn a certain minimum number of credits at The Pennsylvania State University. Consequently, there is a limit to the number of credits which may be earned at another approved institution or through continuing education to meet the minimum requirements of the degree. Moreover, the department or committee in charge of a major program may require a student to do more of the work at the University than specified by the limitations set by the Graduate Faculty. The normal credit load of a full-time graduate student is 8 to 10 credits per term, or the equivalent (see Academic Credit and Employment, page 66).

CONTINUING EDUCATION — A large number of courses carrying credit are given throughout the Commonwealth of Pennsylvania through continuing education. All 400-series courses so offered *may* carry graduate credit for students who have been admitted to the Graduate School. The graduate adviser's signature is required on the official registration form, which the student submits at the designated place of registration for the course.

There is no limit to the number of credits which a student may earn in continuing education, but not more than 10 credits in 400-level courses so earned may be applied toward the minimum requirements for an advanced degree.

REGISTRATION

The responsibility for being properly registered rests with the student. The student is expected to register each term, at least until near completion of the program, for either course work or research

toward the thesis, whether it be on or off campus. In the case of research, the number of credits shall be determined by the amount of time required for the investigation, one credit representing the equivalent of one week of full-time work. In the later stages of the program the situation will determine the requirements for the student's registration.

ADVISERS — To assist the student in planning a program, the head of the major department or program chairman will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of an adviser from the department head and to seek a conference before registration.

TIME OF REGISTRATION — Registration days are indicated in the calendar at the beginning of this catalog.

A student is expected to complete registration during the officially designated period and to attend the first meeting of all classes. If this is impossible because of some emergency or unusual circumstance, the student may be granted permission by the instructor to miss a few class meetings, it being understood that work missed will be made up subsequently. Under these conditions permission may be granted through the Office of Graduate Student Programs for the student to register late. In general, a student who receives permission to register late will be required to reduce the course load in proportion to the length of the absence.

A student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge, regardless of when the student begins attending classes.

CONTINUITY OF REGISTRATION — A student who registers at University Park without interruption for each of the three terms in the September-to-June interval, for all four terms each year, or for summer terms only is considered to have maintained a normal continuity of registration.

Anyone who has interrupted such a normal sequence and now plans to register for work at the University Park Campus is required to apply to the Office of Graduate Student Programs, at least one month before the time of registration, for permission to resume study.

The policy may be summarized for any specific term as follows:

Summer Term — Application required unless the student was registered at University Park for the preceding spring term or the preceding summer term.

Fall Term — Application required unless the student was registered at University Park for the preceding summer term or the preceding spring term.

Winter Term — Application required unless the student was registered at University Park for the preceding fall term.

Spring Term — Application required unless the student was registered at University Park for the preceding winter term.

PROCEDURE — For each registration the student, in consultation with the adviser, prepares a schedule of courses and research designed to fit individual needs. The credit load will be reviewed at the time of registration. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned for work done away from the campus. A student contemplating such work should inquire at the Office of Graduate Student Programs about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed before the close of central registration at University Park.

A student must register for courses audited as well as for those taken for credit.

REGISTRATION NEAR THE COMPLETION OF A PROGRAM — A candidate for the Ph.D. degree is required to register continuously (at least three terms of each four) from the time the comprehensive examination is passed and the three-term residence requirement is met until the thesis is accepted by the doctoral committee, regardless of whether work is being done on the thesis during this interval.

D.Ed. degree candidates and master's students may be required to register for a normal credit load because of their appointment status. If not, and if they have earned more than 90 (D.Ed.) or 30 (master's) credits and have met the requirements for their degrees except for the completion of the thesis, these students may register for as few as two credits per term. A student, other than the Ph.D. degree candidate, who has met the minimum requirements for a degree and is now completing research

and thesis writing off campus is not required to register, even if visits are made to the campus several times each term to see an adviser, unless required to do so within the program.

A student, other than one following the Ph.D. requirement, is not required to register for the final term in order to graduate or in order to make minor revision to the thesis and/or to take a final examination for the degree, unless required to do so by the program.

VISITING AND AUDITING CLASSES — A graduate student registered for a given term who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during that term.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership, such as participating in discussion, doing practicum work, or taking examinations. Registration is not required for the privilege of visiting, and no record appears on the student's transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally enjoy the privileges of a class member. Registration procedures and fee payment are the same as for taking the course for credit. No credit is given, either on completion of the course or at a later time; however, the number of credits assigned to the course appears on the grade report and on the student's transcript. Thus, when a student receives an audit grade, the number of credits audited is shown. The symbol Au shall be used if attendance has been regular, the symbol W if attendance has been unsatisfactory.

A graduate assistant or fellow, who is required to register for a certain minimum number of credits, is not permitted to count audited course credits toward the minimum credits needed. The 1G and 2G language courses are an exception. The student may register for credit or audit beyond the required minimum but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for a course as auditors. However, visiting is not permitted in German 1G and 2G.

In the 1G and 2G courses offered by the language departments, no distinction is made between registering for credit and for audit in considering loads.

THESIS RESEARCH — In registering for thesis research a student uses the appropriate number (600, 610) preceded by the abbreviation designating the major field. The numbers 600 (on campus) and 610 (off campus) are available for credit in thesis research in all graduate major programs.

THESIS PREPARATION — The numbers 601 and 611 are available to Ph.D. degree candidates and are used for special noncredit registration for thesis preparation work. Such candidates must have passed the comprehensive examination and must have met the three-term residence requirement. A candidate registered for SUBJ. 601 is classified as a full-time student, while one registered for SUBJ. 611 is classified as a part-time student.

The numbers 600, 601, 610, and 611 may not always appear in the *Schedule of Classes* for each term.

COMMON COURSES — The following courses for which students may register have been set up for common use by major programs, with University Senate approval, to encourage innovation and provide flexibility in designing graduate programs:

590. **COLLOQUIUM** (1-3) Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.

596. **INDIVIDUAL STUDIES** (1-6) Creative projects, including nonthesis research, which are supervised on an individual basis and which fall outside the scope of formal courses. A specific title may be used in each instance and will be entered on the student's transcript. Multiple offerings may be accommodated by the use of suffixes a, b, etc.

597. **SPECIAL TOPICS** (1-6) Formal courses given on a topical or special interest subject which may be offered infrequently; several different topics may be taught in one year or term. A specific title may be used in each instance and will be entered on the student's transcript. Multiple offerings may be accommodated by the use of suffixes a, b, etc.

602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING** (1-2 per term, maximum of 6) May be offered by any graduate program in a department which also offers undergraduate courses. A graduate program with no counterpart undergraduate program may offer SUBJ. 602 when cooperative arrange-

ments are made with an administrative unit which does not offer graduate degrees but which uses graduate assistants in its teaching. SUBJ. 602 may be offered in any term and is subject to the following restrictions:

1. SUBJ. 602 shall not be counted in fulfilling any specific credit requirement for an advanced degree.
2. SUBJ. 602 shall be graded (A, B, C, D, F).
3. SUBJ. 602 shall not be used in calculating grade-point averages.
4. SUBJ. 602 shall be offered only in those graduate programs wishing to provide opportunity for supervised and graded teaching experience. Enrollment shall be restricted to students for whom the major program is prepared to provide such experience.
5. SUBJ. 602 may, but need not, be counted as a part of the normal credit load for graduate assistants.

ACADEMIC CREDIT AND EMPLOYMENT

To provide flexibility in arranging credit loads for graduate assistants and full-time University staff members, a procedure has been set up whereby the normal credit limits may be changed by permission of the person to whom the student or staff member is responsible for University employment or assistantship assignment. Maintenance of the established credit loads and responsibility for the consequences of a graduate student's change of course load rests with the student and adviser. The course load is a factor in determining whether a graduate student is classified as a full-time or part-time student; has met residence requirements; and is eligible to hold a fellowship, scholarship, assistantship, or departmental or program appointment.

The University takes the position that the facilities of the Graduate School should be made available first to students who can profit from their graduate school experience to the maximum extent. More than doing what is required in courses or in research, the graduate experience is one of living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in discussions, both formal and informal, with faculty members and fellow students. It is an involvement and participation in student affairs, University and Graduate School governance, committee assignments, and personal contribution of effort to the welfare and betterment of the University graduate community. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of, one's specialty. Students who propose schedules of few credits not requiring serious effort, or those who wish to carry overloads of such proportion as to handicap them seriously in achieving maximum quality, find it difficult and often impossible to experience the satisfaction of a well-rounded scholarly attainment.

A graduate student should achieve a balance between academic credit load, employment, and appointment responsibilities which results in classification as a full-time graduate student with all the privileges and responsibilities intrinsic to this classification. The student's full-time classification is certified by the department head or program chairman and is sent to the Office of Graduate Student Programs.*

FULL-TIME ACADEMIC STATUS — In establishing credit loads, a student who in any term is registered for 8 or more credits *or* who holds a quarter-time assistantship and schedules 7 credits *or* who has a half-time assistantship and schedules 5-7 credits is considered to be engaged in full-time academic work for that term.

PART-TIME ACADEMIC STATUS — A student who in any term is registered for fewer than 8 credits and does not hold a half-time or quarter-time assistantship is considered to be engaged in part-time academic work for that term.

FULL-TIME EMPLOYMENT OFF CAMPUS — A candidate for the Ph.D. degree may not count the work of any term toward the residence requirement for this degree while engaged in full-time employment off campus.

BENEFITS AND PRIVILEGES — A student registered for 6 or more credits of course work *or* for

*Full-time University employees and three-quarter-time graduate assistants may meet Ph.D. degree residence requirements by registering for the full number of credits allowable (4 credits per term for full-time University employees, 4-5 credits for three-quarter-time assistants) and by obtaining certification from the department head as being principally engaged in activities relating to their academic programs.

noncredit SUBJ. 601 or who holds a half-time assistantship and is carrying at least 5 credits is entitled to the *nonacademic* student benefits and privileges of a full-time student.

STAFF EMPLOYEE CREDIT STATUS* — A full-time staff employee of the University may schedule 4 credits per term (up to 16 credits per academic year), either for credit or audit.

No member of the faculty in one of the professorial ranks in the University may receive the master's degree or the doctoral degree from the University.

For University staff employees desiring to take graduate degree work, admission to the Graduate School is a first essential.

EMPLOYMENT — Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, whether on campus or off campus, must recognize the time demands of a work schedule in planning an academic program. A student holding a fellowship or scholarship may not accept employment of any kind for service beyond that specifically permitted by the appointment. Graduate assistants may accept concurrent employment outside the University only after obtaining permission from the head of the department providing the assistantship and from the person in charge of the assistant's graduate program. A graduate assistant may not hold a concurrent appointment with the University other than a Fellowship Supplement.

COURSE-NUMBERING SYSTEM — Courses in the series 1-399 are not listed in this catalog because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclass students with at least junior standing and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 75-81 under the specific requirements for the various master's degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.50, and other students who have been granted permission to enroll through the Office of Graduate Student Programs.

The numbers 600 (on campus) and 610 (off campus) are available for credit in thesis research in all graduate major programs. The numbers 601 and 611 do not denote courses but are used for noncredit special registration for thesis preparation by a Ph.D. candidate. Registration under these numbers will maintain status as a student during the interval which begins at the time the student passes the comprehensive examination and meets the three-term residence requirement and ends at the time the doctoral committee accepts the thesis. The student will register for 601 if engaged full time in the preparation of a thesis, or will register for 611 if engaged only part time in thesis preparation. Candidates for the Ph.D. degree do not receive grades for noncredit registrations (601 and 611).

SCHEDULE OF COURSES — A complete list of the courses which will be offered in any specific term is given in the *Schedule of Classes*, which is available at nominal cost from the Scheduling Office approximately four months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

The following grading system is in effect: Any one of five quality grades (A,B,C,D,F) may be given a graduate student for course work or for thesis research. The grade-point equivalents are 4, 3, 2, 1, 0, respectively.

At the 400, 500, and 600 levels, grades of A, B, and C denote graduate credit, whereas D and F are failing grades for graduate students, D being the normal failing grade. A grade of F indicates doubt in the judgment of the instructor of the student's potential for further graduate study.

A minimum grade-point average of 3.00 for work done at the University is required for graduation.

In addition to the quality grades listed above, two symbols, Def. (deferred) and R, may appear on a

*Full-time University employees and three-quarter-time graduate assistants may meet Ph.D. degree residence requirements by registering for the full number of credits allowable (4 credits per term for full-time University employees, 4-5 credits for three-quarter-time assistants) and by obtaining certification from the department head as being principally engaged in activities relating to their academic programs.

student's transcript. If work is incomplete at the end of a term for a reason beyond the student's control, or if very little work remains to be done, the instructor may report Def. in place of a grade, which will appear temporarily on the student's record. The deferral must be removed within six weeks of the beginning of the succeeding term, unless a special extension is granted by the associate dean of the Office of Graduate Student Programs. If the work is completed within the specified period of deferral, and the instructor does not report a passing grade, the Graduate Recorder automatically records a failing grade after duly notifying the department head or program chairman to that effect. No student may be approved for a degree while a grade deferral for a required course remains on the record. Deferred grade cards may be obtained from the Graduate Recorder, 112 Shields Building.

In the case of thesis work, either in progress or completed, and certain courses approved by the University Senate, the instructor may report the symbol R in place of a grade. This symbol indicates that the student has devoted an adequate amount of time to the work scheduled but gives no indication of its quality. When reported for thesis work, this symbol will not influence the grade-point average and remains on the student's transcript permanently if not converted to a quality grade (A, B, C, D, or F) within one term of its recording. Quality grades reported for a given term for thesis work will be included in the cumulative grade-point average. Quality grades reported for research will not apply to R's given for earlier registrations and will not denote the quality of an entire series of R's.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in a degree program will be dropped from the University. A cumulative grade-point average below 3.00 for any term or terms may be considered as evidence of failure to maintain satisfactory scholarship. Action may be initiated by the department or committee in charge of the graduate major or by the chairman of the student's doctoral committee.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of intention to graduate (by filing a diploma card) and to pay the thesis fee at the beginning of the term in which an advanced degree is expected to be received. If the student does not graduate, the diploma card must be reactivated during the actual term of graduation. Deadlines are given in the calendar found at the beginning of this bulletin.

A preliminary graduation list is prepared by the Graduate Recorder soon after the deadline for each term. Transcripts are prepared and checked in the offices of the Graduate School and the Recorder. The records of candidates who appear to have met requirements are forwarded to major and minor department heads or program chairmen for review and recommendation. The final list of approved candidates appears in the commencement program.

Only those transfer credits which have been accepted by the Graduate School and entered upon the student's transcript by the Recorder before the graduate list deadline will be considered in evaluating a student for graduation at the end of that particular term.

Attendance at commencement exercises is expected, but forms for permission to receive the degree in absentia are available in the Office of Graduate Student Programs in 211 Kern Graduate Building and in the Office of Graduate Records in 112 Shields Building. The form must be completed and filed with the Graduate Recorder by the date specified in the Graduate Calendar.

All degrees conferred are tentative until final grade reports have been received and all requirements fulfilled, even though the student's name may have appeared in the commencement program. A student's transcript or diploma, or both, may be withheld until any outstanding financial obligations to the University have been paid.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred by the University. Recognized as different in purpose, the two programs consequently have different requirements in certain respects.

ADMISSION

A student who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major program in which the doctorate is offered may begin working toward a doctoral degree. However, the student has no official status as a doctoral student and no assurance of acceptance as a doctoral candidate until the candidacy examination has been passed. This examination is administered by the major department or graduate program and is given early in the student's program.

It is the policy of the Graduate School not to permit applicants to work for a second doctoral degree. The President, on recommendation of the dean of the Graduate School, will welcome, as guests, holders of earned doctoral degrees who may be visiting the University Park Campus for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the dean of the Graduate School.

GENERAL REQUIREMENTS

No specified number of courses completed or credits earned will assure attainment of the doctorate. The general requirements are based upon a period of residence, the writing of a satisfactory thesis, and the passing of a comprehensive and a final oral examination. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate in some major programs. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly, the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed. degree.

GRADE-POINT AVERAGE

A minimum grade-point average of 3.00 for work done at the University is required for admission to the comprehensive examination and for graduation.

TIME LIMITATION

A student is required to complete the program within seven years from the date of acceptance as a candidate.

OFF-CAMPUS AND TRANSFER CREDITS

Subject to the approval of the adviser and the head of the major department or program chairman, a student may register for research to be done away from the University Park Campus.

A maximum of 30 credits beyond the baccalaureate at an approved school not granting the doctorate in the student's major program may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. A maximum of two full academic years of work (60 credits) beyond the baccalaureate at a graduate school which grants the doctorate in the candidate's major program may be accepted here to apply toward doctoral degree requirements. Advanced standing is awarded for only one master's degree. Academic work to be so transferred must meet the following criteria: (1) It must have been completed within five years prior to the date of admission to the Graduate School of The Pennsylvania State University; (2) it must appear on a graduate transcript; (3) it must be of at least B quality; and (4) it must be deemed applicable to the student's program by the current academic adviser, approved in writing, and submitted to the Graduate School director of admissions.

The following caveat should be noted. Pass-fail grades are not transferable to an advanced degree program unless the "pass" can be substantiated by the former institution as having at least B quality.

A completed master's degree may be transferred to a doctoral program with no intervening time limitation.

ADVISERS AND DOCTORAL COMMITTEES

Following admittance to a degree program, the student should confer with the head of that major department or program concerning procedures and the appointment of an adviser. Arrangement and approval of the details of the student's term-by-term schedule is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major program for this specific duty.

General guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of four or more members of the Graduate Faculty. One member shall be from outside the candidate's major program. This committee is appointed through the Office of Graduate Student Programs, upon recommendation of the head of the major program, after the student is admitted to candidacy. At the discretion of the associate dean, other members may be added to the committee. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. The chairman, with the following exception, must hold senior membership in the Graduate Faculty. An associate member may supervise the research for a doctoral candidate, and, with the approval of the associate dean of the Graduate School, may serve as chairman of a doctoral committee.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after the student's admission to candidacy. It will prepare, give, and evaluate the candidate's examinations, and supervise and approve the thesis. A favorable vote of at least two-thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether another examination may be taken.

The committee will also notify the associate dean when the candidate is ready to have the comprehensive and the final oral examinations scheduled and will report the results of these examinations to the Office of Graduate Student Programs.

COMMUNICATION AND FOREIGN LANGUAGE COMPETENCE

A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School or must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must meet any communication and foreign language requirements which have been established within the major program. The candidate should ascertain specific language requirements by contacting the professor in charge of the program, whose name appears with the program description under **GRADUATE MAJOR PROGRAMS AND COURSES**.

If a candidate is to be examined for knowledge of a foreign language other than French or Spanish, the intention to take the examination must be reported to the secretary of the language department by the end of the first week of classes for the term during which the examination is to be taken. This date is one week prior to the examination date. This written examination will be administered on dates announced for each term in the Graduate Calendar at the beginning of this catalog.

The Pennsylvania State University has been named by Educational Testing Service as a testing center for the administration of the written tests for students to be examined in French or Spanish. Students wishing to make application to take these tests should, at their earliest convenience, check with the Office of Examination Services, 207 Mitchell Building, University Park, PA 16802. A test fee of \$12 is payable at the time of application. Times and places of tests will be given when the test application is filed.

Candidates for the Doctor of Education degree may be required to demonstrate competence in foreign languages.

CANDIDACY EXAMINATION

The candidacy examination is administered by the Graduate Faculty in the graduate major program and should be taken early in the student's program. The nature of the examination varies with the program and may be the master's examination if so allowed. The decision to admit or not to admit a student to candidacy must be made by the Graduate Faculty or a designated committee of Graduate Faculty. For the Ph.D. student the examination may be given after at least 12 credits have been earned in graduate

courses beyond the baccalaureate. The examination must be taken within three terms after having earned 24 credits.

For the D.Ed. student, the examination should be given when the student has earned a total of approximately 30 credits, including the master's program and work done elsewhere. A student transferring from another graduate school with 30 or more transfer credits must take the candidacy examination prior to earning more than 10 credits here.

COMPREHENSIVE EXAMINATION

When a candidate for the Ph.D. or D.Ed. degree has substantially completed the course work, a comprehensive examination covering the major program and minor field of study is required.

A candidate for the Ph.D. must have satisfied the communication and foreign language requirement before taking the examination.

All candidates are required to have a minimum grade-point average of 3.00 for work done at the University at the time the comprehensive examination is given.

The examination is officially scheduled and announced by the associate dean for graduate student programs upon recommendation of the doctoral committee. It is given and evaluated by the doctoral committee and may be *either written or oral, or both*. A favorable vote of at least two-thirds of the members of the committee is required for passing. In case of failure it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The results are reported to the Office of Graduate Student Programs and will be entered on the candidate's official record.

When a period of more than five years has elapsed between the passing of the comprehensive examination and the completion of the program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

FINAL ORAL EXAMINATION

The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the associate dean for graduate student programs, on the recommendation of the doctoral committee, to take a final examination. Normally the final oral examination may not be scheduled until at least three months have elapsed after the comprehensive examination was passed, although the associate dean may grant a waiver in the case of an outstanding student. The deadline for holding the examination is seven weeks before commencement. It is the responsibility of the doctoral candidate to provide a copy of the thesis to each member of the doctoral committee at least one week before the date of the scheduled examination.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the candidate's whole program of study without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two-thirds of the members of the committee is required for passing. The results of the examination are reported to the Office of Graduate Student Programs and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether another examination may be taken.

PH.D. — ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation; (2) the preparation of a thesis involving independent research; and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

RESIDENCE REQUIREMENTS

There is no required minimum of credits or terms of study, but over some twelve-month period during

the interval between admission to candidacy and completion of the Ph.D. program the candidate must spend at least three terms (which may include the term in which the candidacy examination is taken) as a registered full-time student engaged in academic work on the University Park Campus or at The Milton S. Hershey Medical Center. Full-time University employees must be certified by the department as devoting half time or more to graduate studies and/or thesis research to meet the degree requirements (see Academic Credit and Employment, page 66).

CONTINUOUS REGISTRATION

After a student has passed the comprehensive examination *and* met the three-term residence requirement, no further registration for credit will be required by the Graduate School. However, status as a student must be maintained by registering continuously (at least three terms of each four, beginning with the first term after both of the requirements mentioned above have been met) until the thesis is accepted by the doctoral committee. This registration may be for (1) noncredit 601 or 611 only, with payment of the special thesis preparation fee; (2) noncredit 601 or 611 with payment of the special thesis preparation fee plus course registration at the regular per credit fee; or (3) full-time course credits with payment of the regular tuition fee. Grades are not given for noncredit 601 or 611. Failure to maintain registration will result in termination of student status.

MINOR FIELD

A Ph.D. candidate is not required by the Graduate Faculty to have a minor field of study. However, a department or a committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of the doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the master's degree, of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major program and the minor field.

THESIS

The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal an ability on the part of the candidate to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis must be submitted to the Office of Theses and Publications not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin*, which gives details concerning format, paper, typing, and other requirements, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building. Following editorial review of the thesis by this office, it is expected that the student will submit a copy of the thesis, incorporating format corrections, to the office of the department or program head.

D.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge and concurrence by the dean of the College, may also be offered in any other field appropriate to the preparation of teachers which has been approved for the doctorate.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles in classroom instruction, supervision of instruction, administra-

tion, or as a consulting specialist in certain educational areas; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successfully passing examinations, i.e., showing a satisfactory grasp of the field of specialization and its relation to allied educational areas.

RESIDENCE REQUIREMENTS

A minimum of nine terms of full-time graduate study and research (10 credits per term), or their equivalent in credits (90 credits), of which at least 30 credits must be earned in residence, is required for the D.Ed. degree. The D.Ed. candidate may meet the requirements by attending summer terms unless the major department requires a period of registration in other terms or in consecutive terms at University Park. A candidate may register for a maximum of 30 credits of research in absentia, but none of these may count toward the minimum of 30 credits which must be earned at the University Park Campus. It is expected that students will register for a minimum of 15 credits of thesis research. The maximum credit load permitted a student who is employed full time is 4 credits per term.

MAJOR PROGRAM AND MINOR FIELD

The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major program of study.

A candidate choosing a major outside the field of education (such as speech, geography, or history) shall have a minor consisting of no fewer than 15 credits in education, including those applied toward the master's degree, as approved early in the major program by a faculty adviser designated by the College of Education.

A candidate choosing a major in one of the major programs in education must also choose either a minor or a group of general studies with the approval of the major program chairman. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside those of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields outside those of education considered by the major program committee to have significance and value for the candidate.

COMPREHENSIVE EXAMINATION

In addition to demonstrating a high level of competence in the subject matter in the major program and minor field, each candidate must show, by a comprehensive examination, an understanding of current theories of education and the ability to apply the techniques and findings of educational research so far as they bear upon the teaching of the subject matter. The candidate must also be able to understand and contribute to the technical and professional literature in the field, and to criticize learned procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include competence in the use of statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates are required to have a minimum grade-point average of 3.00 for work done at the University at the time the comprehensive examination is given.

THESIS

Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought, as well as ability and originality in the application of educational principles or in the development of new generalizations under scientific controls. A thesis may be based upon a product or project of a professional nature, provided scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis must be submitted to the Office of Theses and Publications not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin*, which gives details concerning format, paper, typing, and other requirements, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building. Following editorial review of the thesis by this office, it is expected that the student will submit a copy of the thesis, incorporating format corrections, to the office of the department or program head.

MASTER'S DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees, academic and professional. Of the fifteen master's degrees conferred, the Master of Arts and Master of Science are academic in nature. The professional degrees conferred are Master of Administration, Master of Agriculture, Master of Architecture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forest Resources, Master of Music, Master of Psychosocial Science, Master of Public Administration, and Master of Regional Planning.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements as specified below under Additional Specific Requirements.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts the continuity of registration faces the possibility of not being granted permission to return.

GRADE-POINT AVERAGE

A minimum grade-point average of 3.00 for work done at the University is required for graduation.

TIME LIMITATION

All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

ADMISSION

In addition to the general University requirements for admission set forth at the beginning of this catalog, adequate undergraduate preparation is required in the program in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of program and can be ascertained from the descriptive statement appearing under the major program heading in the latter portion of this catalog. An applicant who meets the necessary grade-point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and be allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the necessary period of residence. An applicant for admission to the M.Ed. program in most major programs is required to have had at least 18 credits in education and related psychology, and in certain major programs may be required to have had practice teaching.

After admission to a degree program, a student should confer with the head of the major department or program concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major department or program in which the student is specializing. The adviser or the committee assists the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments or programs in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department or program.

TRANSFER CREDIT

Subject to the limitations given, a maximum of 10 credits of high-quality graduate work done at another institution may be applied toward the requirements for the master's degree. However, credits earned to complete a previous master's degree may not be applied to a second master's degree program at The Pennsylvania State University.

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program. Approval to apply any transferred credits toward a degree program must be granted by the student's academic adviser, and the adviser must notify the Graduate School director of admissions, in writing, when such approval is granted. Transferred academic work must have been completed within five years prior to the date of admission to the Graduate School of The Pennsylvania State University, must be of at least B quality, and must appear on a graduate transcript.

Pass-fail grades are not transferable to an advanced degree program unless the "Pass" can be substantiated by the former institution as having at least B quality.

Forms for transfer of credit may be obtained from the Office of Graduate Admissions, 201 Kern Graduate Building.

EXAMINATIONS

A candidate may be required to pass in a satisfactory manner written or oral examinations designated by the program head. A candidate should consult the major department or program for special requirements.

Examinations to establish credit for work done in absentia or without formal class work may be used to remove undergraduate deficiencies, but *not* to earn credits toward an advanced degree. Arrangements are made by the student directly with the major department head or program chairman.

Graduate Record Examinations are designed to test information and abilities in basic fields of knowledge. Provisions are made on the campus for administering these examinations at scheduled times and upon request of students or department program chairmen. Informational materials may be obtained at the Graduate School Information Center on the first floor of Kern Graduate Building.

ENGLISH PROFICIENCY OF FOREIGN STUDENTS

Entering graduate students from countries other than the United States are required to demonstrate high-level competence in the use of the English language, including reading, writing, speaking, and listening. Upon arrival at the University, such students are requested to report to the Office of International Student Affairs, 111 Kern Graduate Building, where an appointment for the English language proficiency interview will be made. Students with an obvious command of English may be exempted from formal testing; others will be scheduled for a series of proficiency tests. The Graduate School of The Pennsylvania State University requires all foreign graduate students who are working toward a degree to meet the established English language proficiency requirement. Under ordinary circumstances, it is expected that the master's candidate will demonstrate proficiency during the first or second term of graduate study. Doctoral candidates must pass the proficiency test before they may be admitted to candidacy for the degree. Remedial work will be prescribed as need is indicated by the test results.

Before a foreign student can be accepted for enrollment at The Milton S. Hershey Medical Center and in many graduate major programs, a high-level competence in the use of the English language must be demonstrated by successful performance on the TOEFL (Test of English as a Foreign Language). Information on the time and place that this test is given in a student's geographical area can be obtained by writing to the Educational Testing Service, Box 592, Princeton, NJ 08540.

M.A. and M.S. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred. Programs for both degrees are strongly oriented toward research.

A minimum of 30 graduate credits is required, of which at least 20 must be earned at an established graduate campus of the University. A minor is not required of all candidates for the M.A. or M.S. degree. A department or committee in charge of a major program may require a candidate to offer work in a minor field, or the minor may be elected with the permission of the student's committee.

A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major program and minor field.

The major department or the committee in charge of the major program is the judge as to the suitability of a field for the minor and of its relevance to the major. The minor field department has the responsibility of accepting or rejecting students, advising on courses to be taken by the candidate in the field, examining the candidate in the area of studies undertaken in the field, and certifying that the minor requirements have been met.

At least 18 credits in the 500 and 600 series, combined, must be included in the program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed in the major program. A thesis is required of many candidates for these degrees. Details are given in the introductory paragraphs under the major program headings in the latter part of this catalog. If a student is required to write a thesis, at least 6 credits in thesis research (600 or 610) must be included in the program. If no thesis is required, at least 18 credits must be in 500-level courses.

A thesis is prepared under the direction of the department or program in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off campus. To do so, satisfactory arrangements must be made in advance with the adviser and the head of the major department or program.

Those candidates who are not required to write a thesis must present a suitable essay or paper. Its nature and extent shall be determined by the major program. The department head or program chairman shall report to the Office of Graduate Student Programs the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The program head may require one or more copies of the essay for the program's library or other files.

Some programs in the field of education offer the M.S. degree but prefer to admit students into the M.Ed. degree program. Other programs which emphasize research prefer to admit only students interested in pursuing the Ph.D. degree.

Requirements for the M.A. degree at the Capitol Campus differ somewhat from the above and are outlined under the major programs in American Studies and Humanities. These programs are available only at the Capitol Campus.

A *Thesis Information Bulletin*, which gives details concerning format, paper, typing, and other requirements, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building. Following editorial review of the thesis by this office, it is expected that the student will submit a copy of the thesis, incorporating format corrections, to the office of the department or program head.

M.Adm. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Administration degree program is offered only at the Capitol Campus. It is intended to meet the professional needs of practicing and potential administrators in the fields of business and engineering. Two options are offered: (1) the business administration option is intended for students who desire to pursue an administrative career in business, industry, or institutions; and (2) the engineering administration option prepares individuals for management positions in engineering, scientific, and technical organizations. Each student is required to complete a professional paper of the quality, if not the theoretical depth, of a thesis.

A description of the Administration program appears subsequently in this catalog. Further information can be obtained from the Capitol Campus.

M.Agr. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Agriculture is a professional degree. Programs leading to this degree provide opportunities for students to increase their knowledge and competences in the various phases of agriculture. A student, according to individual objectives, may obtain intensive training encompassing a wide spectrum of subject matter area or intensive training in a specialized area. The emphasis of the program is to enable students to develop skill as professional practitioners in the communication of technical knowledge and its application to the solution of current and future technical, economic, and social problems of individuals and groups.

The head of the department or program chairman shall appoint a three-member committee to guide and monitor the candidate's professional development. Members of this committee must represent at least two departments. The chairman of the appointed committee shall serve as the candidate's adviser. The candidate will inform the committee of personal aspirations and background early in the program. The committee will suggest to the student how best to achieve these goals and the standard of professional competence required for the Master of Agriculture degree.

A minimum of 30 graduate credits is required, of which 20 credits must be earned in residence at the University Park Campus. A maximum of 10 credits may be earned in special problem-type courses.

The candidate must present an acceptable paper on a selected professional problem or a report of internship training. Up to 3 graduate credits will be given for an acceptable paper. The candidate may be required to provide one or more copies of the paper for the University.

The candidate's committee shall report, through the department head or program chairman, to the Office of Graduate Student Programs the title of the paper and whether the paper and the candidate's academic performance were considered satisfactory.

M.Arch. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Architecture is a professional degree and is planned to provide the depth and breadth of knowledge needed to enter the architectural profession and become a licensed professional architect following the required period of internship. Admission requirements include the equivalent of 39 credits in design-research work and a statement of purpose concerning the professional aims of the candidate.

A minimum of 60 graduate credits is required, of which 36 must be at the 500 level and 24 at the 400 level. A minimum of 30 credits must be taken at the University Park Campus. A thesis is optional. If a thesis is written, 6 credits of Arch. 600 must be completed. Professional areas of study include building design and architectural programming.

M.B.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The purpose of the Master of Business Administration degree program is to develop professional managerial knowledge and skills as these are applied to the decisions in complex organizations. Teaching focuses upon the techniques, the concepts, and the skills important to modern administrators.

A minimum of 45 graduate credits is required, all at the 500 level. Thirty credits must be in specified core courses. Also required are 15 credits in major field courses and electives (including a professional paper). Work for this degree may be started in the fall term only. Applications must include the results of the Graduate Management Admission Test.

M.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in education. They should be distinguished carefully from the research-oriented programs which lead to the academic degrees of Master of Arts or Master of Science. In most major programs the requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned at an established graduate campus of the University; at least 24 must be in course work. This degree is also offered at the Capitol Campus and the King of Prussia Graduate Center.

MAJOR PROGRAMS IN THE FIELDS OF EDUCATION

A student may major in one of the approved programs in education, such as art education, educational psychology, or home economics education, and proceed under the guidance of the appropriate major in education. At least 12 of the 24 credits in course work must be taken at the 500 level.

A program of this type requires at least 6 credits to be earned outside the programs in education.

MAJOR PROGRAMS OUTSIDE THE FIELDS OF EDUCATION

A student who is preparing to teach in a specific subject-matter field, such as geography, mathematics, or German, may choose such a program as a major and take a majority of work in it under the guidance of the department offering that major. A student wishing to work in a broader area may choose a major such as biological science, earth sciences, or social studies and take at least 24 credits in the area under the guidance of the committee in charge of the major.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits may be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology.

THESIS OR PAPER

Six credits may be granted for an approved thesis. A candidate who does not elect to write a thesis is required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of this piece of writing, whether it be required in connection with a course or independent of course work, and when it is to be undertaken shall be determined by the major program. The department or division head or program chairman shall report to the Office of Graduate Student Programs the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the department or division head or program chairman to require one or more copies of the essay for the department's, division's, or program's library or other files.

M.Eng. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Engineering provide training for advanced professional competence in the several fields of engineering. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required, of which 20 must be earned at an established graduate campus of the University. At least 12 credits must be earned in graduate courses (500 series).

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in

its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

Work for this degree is not required to be done specifically on the University Park Campus. A complete program of study can be pursued at the Capitol Campus, at Behrend College, or at the King of Prussia Graduate Center of The Pennsylvania State University.

M.E.P.C. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Environmental Pollution Control is an intercollege professional degree designed for students who are interested in pursuing a career in the field of environmental pollution control. Special requirements include 9 credits of core courses covering air and water pollution control and solid waste management and participation in the environmental pollution control seminar program. A minimum of 30 graduate credits is required, of which at least 9 must be at the 500 level and 20 must be taken at the University Park Campus. A thesis is optional. If a thesis is written, at least 6 credits of thesis research (600 or 610) must be taken. Those who select the nonthesis option must submit a paper.

M.F.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Fine Arts provide training for increased professional competence in the several specialized areas of the arts. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts with a major in art or theatre arts.

A minimum of 48 credits is required, of which at least 38 must be earned at the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate in a particular field.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect of the program; the project and monograph shall represent a minimum of 6 credits on the 600 level.

M.F.R. — ADDITIONAL SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Forest Resources provides training for increased professional competence in the several specialized areas of forest resource management and forest products. It should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Science with a major in forest resources.

A minimum of 30 graduate credits is required, of which at least 20 must be earned at an established graduate campus of the University. At least 12 credits must be in courses at the 500 level, excluding F.P. 596, For. 596, and Wildl. 596.

A candidate for the degree of Master of Forest Resources may elect a minor with the permission of the committee. A minor consists of no fewer than 6 credits of integrated work in one field related to, but

different from, that of the major. A minor program must meet the approval of the department or committee responsible for the minor field.

Each candidate is required to submit an acceptable paper based on 6 to 9 credits of individual studies.

M.Mus. — ADDITIONAL SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Music provides training for increased professional competence in music. It should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Arts with a major in music history.

A minimum of 48 credits is required, of which at least 38 must be earned at the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect of the program; the project and monograph shall represent a minimum of 6 credits on the 600 level.

M.P.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration in local, state, and national governmental jurisdictions or in international, private, or voluntary agencies. The M.P.A. degree is offered at the University Park Campus, the Capitol Campus, and the King of Prussia Graduate Center.

The M.P.A. degree offered at University Park and King of Prussia requires a minimum of 30 graduate credits, of which 20 must be earned at the University Park or King of Prussia campuses. The greater portion of the courses must be at the 500 level. An M.P.A. essay or paper will also be required but will carry no graduate credit. A comprehensive final examination will be given to all candidates.

The M.P.A. degree offered at the Capitol Campus at Middletown requires a minimum of 39 graduate credits including a 9-credit field study (internship) experience and a professional master's project. There is no comprehensive final examination, but an oral defense of the master's project report is required.

The program leading to the Master of Public Administration degree should be distinguished from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science, in which the candidate may specialize in public administration.

M.Ps.Sc. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Psychosocial Science degree, community psychology option, is a non-traditional program with an emphasis on practicum experience. The program is concerned with equipping students with some of the skills necessary to cope effectively with the multifaceted problems facing communities. Students should be able to recognize problems, to outline and implement possible solutions to these problems, and to evaluate the effectiveness of the solutions.

Thirty-three graduate credits are required, 21 at the 500 level. A major portion of this degree is field

work under the supervision of a faculty member. A paper is a necessary part of the practicum experience. An oral defense of the paper is required.

M.R.P. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Regional Planning is a professional degree for students interested in a coordinated attack on the problems of regional and community development and resource management. The program is intended to acquaint the student with rational programs of spatial allocation of land uses and facilities, maintenance of cultural and aesthetic values, and legal and governmental techniques for their implementation.

For the M.R.P. degree at the University Park Campus, a minimum of 54 approved graduate credits is required, of which 36 must be earned at a graduate campus of the University. Six graduate credits will be earned in preparing (1) a thesis or (2) a professional paper comparable in quality and scope to a graduate thesis.

The M.R.P. degree at the Capitol Campus at Middletown requires a minimum of 45 graduate credits, 35 of which are required in planning courses, at least 6 of which will be earned in preparing (1) a problem-oriented thesis, or (2) an individual project report comparable in quality and scope to a graduate thesis, or (3) a project written in a terminal integrative course in regional planning.

GRADUATE MAJOR PROGRAMS OF STUDY

The following degrees are the ones normally conferred in each of the designated major programs. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head or program chairman and the dean of the Graduate School. For example, the M.Ed. has been authorized for all of the programs below in which a master's degree is conferred provided the program is appropriate to the preparation of teachers.

- *Acoustics — Ph.D., M.S., M.Eng.
- Administration (Capitol) — M.Adm.
- Aerospace Engineering — Ph.D., M.S.
- Agricultural Economics — Ph.D., M.S., M.Agr.
- Agricultural Education — Ph.D., D.Ed., M.S., M.Ed.
- Agricultural Engineering — Ph.D., M.S.
- Agromony — Ph.D., M.S., M.Agr.
- American Studies (Capitol) — M.A.
- Anatomy (Hershey) — Ph.D., M.S.
- Animal Industry — Ph.D., M.S., M.Agr.
- Animal Nutrition — Ph.D., M.S.
- Anthropology — Ph.D., M.A.
- Architectural Engineering — M.S.
- Architecture — M.S., M.Arch.
- Art — M.A., M.F.A.
- Art Education — Ph.D., D.Ed., M.S., M.Ed.
- Art History — Ph.D., M.A.
- Astronomy — Ph.D., M.S.
- Biochemistry — Ph.D., M.S.
- *Bioengineering — Ph.D., M.S.
- Biological Chemistry (Hershey) — Ph.D., M.S.
- Biological Science — D.Ed., M.Ed.
- Biology — Ph.D., M.S.
- Biophysics — Ph.D., M.S.
- Botany — Ph.D., M.S.
- Business Administration — Ph.D., M.S., M.B.A.
- Ceramic Science — Ph.D., M.S.
- Chemical Engineering — Ph.D., M.S.
- Chemistry — Ph.D., M.S.
- Civil Engineering — Ph.D., M.S., M.Eng.
- Classics — M.A.
- Community Systems Planning and Development — Ph.D., M.S.
- Comparative Literature — Ph.D., M.A.
- Computer Science — Ph.D., M.S.
- Counselor Education — Ph.D., D.Ed., M.S., M.Ed.
- Curriculum and Instruction — Ph.D., D.Ed., M.S., M.Ed.
- Dairy Science — Ph.D., M.S.
- Developmental and Remedial Reading — M.Ed.
- Earth Sciences — D.Ed., M.Ed.
- *Ecology — Ph.D., M.S.
- Economics — Ph.D., M.A., M.Ed.
- Education of Exceptional Children — Ph.D., D.Ed., M.S., M.Ed.
- Educational Administration — Ph.D., D.Ed., M.S., M.Ed.
- Educational Psychology — Ph.D., M.S.
- Electrical Engineering — Ph.D., M.S.
- Engineering Mechanics — Ph.D., M.S., M.Eng.
- Engineering Science — M.S.
- Engineering Science (Behrend, King of Prussia, Capitol) — M.Eng.
- English — Ph.D., D.Ed., M.A., M.Ed.
- Entomology — Ph.D., M.S., M.Agr.
- Environmental Engineering — M.S., M.Eng., Ph.D.
- *Environmental Pollution Control — M.S., M.Eng., M.E.P.C.
- Extension Education — M.Agr., M.Ed.
- Food Science — Ph.D., M.S.
- Forest Resources — Ph.D., M.S., M.F.R.
- French — Ph.D., D.Ed., M.A.
- Fuel Science — Ph.D., M.S.
- *Genetics (U.P., Hershey) — Ph.D., M.S.
- **Geochemistry and Mineralogy — Ph.D., M.S.
- Geography — Ph.D., M.S.
- **Geology — Ph.D., M.S.
- **Geophysics — Ph.D., M.S.
- German — Ph.D., M.A., M.Ed.
- Higher Education — D.Ed., M.Ed.
- History — Ph.D., D.Ed., M.A., M.Ed.
- Home Economics Education — Ph.D., D.Ed., M.S., M.Ed.
- Horticulture — Ph.D., M.S., M.Agr.
- Human Development and Family Studies — Ph.D., D.Ed., M.S., M.Ed.

*Intercollege Graduate Program

**See Geosciences

Humanities (Capitol) — M.A.
 Industrial Engineering — Ph.D., M.S.,
 M.Eng. (King of Prussia, M.Eng.)
 Journalism — M.A.
 Laboratory Animal Medicine (Hershey) —
 M.S.
 Linguistics — Ph.D., M.A.
 Man-Environment Relations — Ph.D.,
 D.Ed., M.S., M.Ed.
 Mathematics — Ph.D., D.Ed., M.A.,
 M.Ed.
 Mathematics (King of Prussia) — M.Ed.
 Mechanical Engineering — Ph.D., M.S.,
 M.Eng.
 Metallurgy — Ph.D., M.S.
 Meteorology — Ph.D., M.S.
 Microbiology — Ph.D., M.S.
 Microbiology (Hershey) — Ph.D., M.S.
 Mineral Economics — Ph.D., M.S.
 Mineral Engineering Management —
 M.Eng.
 Mineral Processing — Ph.D., M.S.
 Mining Engineering — Ph.D., M.S.,
 M.Eng.
 Music — M.A., M.Mus.
 Music Education — D.Ed., M.Ed.
 Nuclear Engineering — Ph.D., M.S.,
 M.Eng.
 Nursing — M.S.
 Nutrition — Ph.D., D.Ed., M.S., M.Ed.
 Nutrition in Public Health — M.S.
 †Operations Research — Ph.D., M.S.
 Petroleum and Natural Gas Engineering —
 Ph.D., M.S.
 Pharmacology (Hershey) — Ph.D., M.S.
 Philosophy — Ph.D., D.Ed., M.A.,
 M.Ed.
 Physical Education — Ph.D., D.Ed.,
 M.S., M.Ed.

Physics — Ph.D., D.Ed., M.S., M.Ed.
 *Physiology (U.P., Hershey) — Ph.D.,
 M.S.
 Plant Pathology — Ph.D., M.S., M.Agr.
 Political Science — Ph.D., M.A.
 Poultry Science — Ph.D., M.S.
 Psychology — Ph.D., M.S.
 Psychosocial Science (Capitol) —
 M.Ps.Sc.
 Public Administration — M.P.A.
 Public Administration (Capitol) —
 M.P.A.
 Recreation and Parks — M.S., M.Ed.
 *Regional Planning — M.R.P.
 Religious Studies — Ph.D., M.A.
 Rural Sociology — Ph.D., M.S., M.Agr.
 *School Psychology — D.Ed., M.S., M.Ed.
 Slavic Languages and Literatures — M.A.
 Social Studies — M.Ed.
 Sociology — Ph.D., M.A.
 *Solid State Science — Ph.D., M.S.
 Spanish — Ph.D., D.Ed., M.A., M.Ed.
 Speech Communication — Ph.D., D.Ed.,
 M.A.
 Speech Pathology and Audiology — Ph.D.,
 D.Ed., M.S., M.Ed.
 Statistics — Ph.D., M.S., M.A.
 Teaching and Curriculum (Capitol) —
 M.Ed.
 Theatre Arts — M.A., M.F.A.
 Urban and Regional Planning (Capitol) —
 M.R.P.
 Veterinary Science — Ph.D., M.S.
 *Vocational Education — Ph.D., D.Ed.
 Vocational Industrial Education —
 Ph.D., D.Ed., M.S., M.Ed.
 Wildlife Management — M.S.
 Zoology — Ph.D., M.S.

*Intercollege Graduate Program

†Dual-title Program Option

GRADUATE MAJOR PROGRAMS AND COURSES

ACOUSTICS (ACS)

JIRI TICHY, *Chairman of the Committee on Acoustics*
Applied Research Laboratory, Applied Science Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Ackerman, Baker, Brown, Brubaker, Fenlon, Hayek, Johnson, Martin Michael, Neubert, Pigott, Reethof, Rowlands, Sibul, Skudrzyk, Snowden, Thompson, and Tichy.

Graduate Faculty: Associate Members Andrews, Farwell, Frost, Lauchle, Lawther, Macaluso, McDaniel, Miller, Prout, Ricker, Stuart, and Wilson.

The aim of this intercollege program is to enable the student interested in acoustics to obtain an integrated program of courses covering the fundamentals of acoustical science and the biological, communications, and engineering applications of acoustics.

Programs are arranged through a selection of appropriate courses offered by several departments in the Colleges of Science, Engineering, Education, and Arts and Architecture, as well as those specifically in the area of acoustics.

Areas of concentration include acoustic signal processing, architectural and building acoustics, noise and vibration, physical acoustics, speech and hearing, and underwater acoustics. Thesis research in the various areas may be conducted in relevant departments and in the Applied Research Laboratory.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by competence in the use of computer language, as well as a reading knowledge of a foreign language.

Entering students should hold a bachelor's degree in physics, biology, engineering, architecture, mathematics, psychology, speech and hearing, or in a closely related field; and they should have had at least one year of physics and mathematics including integral calculus. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

In addition to the acoustics courses listed below, the following courses on acoustics and closely related areas are available: Aersp. 412, 444, 506, 511, 515, 516, 517; A.E. 458, 542; E.E. 459, 560, 561, 562; E.Mch. 401, 412, 516, 521, 522, 524A,B, 525, 527, 528, 570; M.E. 458, 522; Phys. 443, 533; Sp.Com. 413, 431; S.P.A. 430, 434, 522, 531, 532, 534.

ACOUSTICS (ACS)

401. GENERAL ACOUSTICS (3)

402. FUNDAMENTALS OF ACOUSTICS (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

511. UNDERWATER SOUND PROPAGATION (3) Theoretical and empirical treatment of sound propagation in the ocean, including effects of the environment, characteristics of targets, and transducers.

512. SONAR ENGINEERING (3) Theoretical and empirical treatment of problems related to the use of underwater sound in target detection and ranging.

513. MODERN ACOUSTIC SIGNAL PROCESSING (3) Probability review, representation of signals, noise processes, optimum filtering, ambiguity functions, linear and nonlinear signal processing, application to sonar systems.

*A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department or program offering the course.

A department or major program may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400- and 500-series courses an individual student may schedule fewer credits than the maximum number but in no case more than the maximum number authorized.

All courses listed under graduate major programs may not be required in the particular major.

514. **ELECTROACOUSTIC TRANSDUCERS (3)** The theory, design, and calibration of passive, linear, reciprocal electroacoustic transducers for use in both air and water media. Prerequisite: Phys. 443.
515. **ACOUSTICS IN FLUID MEDIA (3)** Wave propagation in stationary and moving fluids; acoustic radiation and scattering; standing waves in ducts and cavities. Prerequisites: E.Mch. 524A, Phys. 443.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

ADMINISTRATION (ADMIN)

ROBERT J. BROWN, *In Charge of the Graduate Program in Administration at Capitol Campus*
Middletown, PA 17057

Degree Conferred: M.Adm.

Graduate Faculty: Senior Members Gilmore and Yaney.

Graduate Faculty: Associate Members Blumberg, R. Brown, T. Brown, Chisholm, DeRooy, Dexter, Frey, McKenna, Murli, Murty, Onkvisit, Poore, Pringle, and Shaw.

This program is intended to meet the professional needs of practicing and potential administrators. Options are available in business administration and engineering administration. The business administration option is intended for those students who desire to pursue an administrative career in commerce, business, or industry. The engineering administration option is intended for students who wish to include courses in engineering and operations research as part of their program.

To obtain the degree three foundation courses must be satisfied, and a program of 33-47 credits must be completed. Research competence will be demonstrated by completion of the master's project. Students must register for Bus. 554 (Master's Project) for a total of 3 credits before, or at the same time as, they register for the last 6 credits of other course work.

For admission to the Master of Administration program, the student must have a baccalaureate degree from an accredited institution. Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

Applicants are required to take the Graduate Management Admissions Test.

The program is offered only at the Capitol Campus.

COURSES*

ADMIN. 500. **ADMINISTRATIVE THEORY (3)** History, significance and functions of administration, theories of leadership, authority, decision making, rationality, and efficiency.

ADMIN. 505. **PERSONNEL MANAGEMENT (3)** Problems in effectively selecting, utilizing, and developing human resources from the viewpoint of the total organization — both private and public.

ADMIN. 510. **ORGANIZATION BEHAVIOR (3)** Examination of concepts of human behavior in formal organizations, systems analysis, conceptual models, and decision processes.

ADMIN. 515. **LABOR MANAGEMENT RELATIONS (3)** Labor relations issues; collective bargaining agreement, negotiations, and administration; legal framework of collective bargaining; labor relations in larger social context. Prerequisite: Admin. 500.

ADMIN. 520. **ADMINISTRATIVE MODELS (3)** Formulation and solution of decision models for administrative problems. Analysis of decision making under certainty, risk, and uncertainty. Prerequisites: Bus. 492, 493.

*Course descriptions not given below can be found under the designated field of study.

ADMIN. 552. MULTIVARIATE STATISTICAL ANALYSIS (3) Application of statistical methods for analyzing the relationships between two or more variables, such as multiple regression. Prerequisite: 6 credits in statistics or Bus. 493.

ADMIN. 556. ECONOMIC AND BUSINESS FORECASTING (3) Application and evaluation of methods for forecasting regional economic change and business activity. Prerequisites: Bus. 380, Econ. 310.

ADMIN. 560. SAMPLING THEORY AND PRACTICE (3) Study of scientific method of obtaining representative samples, collection of information, techniques of estimation. Prerequisite: Bus. 493.

ADMIN. 590. COLLOQUIUM (1-3)

ADMIN. 596. INDIVIDUAL STUDIES (1-6)

ADMIN. 597. SPECIAL TOPICS (1-6)

†BUS. 398G. COMPUTER WORKSHOP (1) Data processing and analysis with SPSS supplemented with an introduction to FORTRAN IV. Open only to graduate students.

BUS. 522. OPERATIONS MANAGEMENT (3) Integration and application of decision making to operational and policy problems within the business firm. Prerequisite: Admin. 520.

BUS. 530. FINANCIAL MANAGEMENT (3) Theory and techniques of financial management. Cover analysis, planning and control; sources of funds; allocation of funds; special situation analysis. Prerequisites: Admin. 520, Bus. 320.

BUS. 540. FINANCIAL AND MANAGERIAL ACCOUNTING (3) Fundamental financial and managerial accounting concepts and issues from the viewpoint of the report user. Prerequisite: 6 credits of introductory accounting.

BUS. 554. MASTER'S PROJECT (1-3) Development of an original master's project in the student's area of professional interest.

BUS. 570. MARKETING MANAGEMENT (3) Analysis of management's marketing problems, including marketing analyses, pricing, channels of distribution, promotion, competition, product strategies, and marketing research.

BUS. 584. GOVERNMENT AND BUSINESS (3) Theory, practice, and impact of government regulation of business. Prerequisite: Econ. 410 or 417.

*BUS. 588. BUSINESS POLICY FORMULATION (3) Analysis of administrative problems from a total organization viewpoint. Case studies of actual organizations are used for analysis. Prerequisites: all core and tool courses.

B.LOG. 538. LOGISTICS SYSTEMS MANAGEMENT (3)

B.LOG. 541. SOCIOECONOMIC ANALYSIS IN TRANSPORTATION (3)

I.B. 501. THE INTERNATIONAL ENVIRONMENT (3)

I.E. 508. OPERATIONS RESEARCH: INVENTORY MODELS (3)

I.E. 509. OPERATIONS RESEARCH: WAITING LINE MODELS (3)

I.E. 510. MATHEMATICAL PROGRAMMING (3)

MKTG. 530. CONSUMER AND MARKET BEHAVIOR (3)

*Course to be taken during student's last term — recommend tool courses be completed.

†No graduate credit is given for this course.

AEROSPACE ENGINEERING (AERSP)

BARNES W. McCORMICK, *Head of the Department*
233 Hammond Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Eisenhuth, Holl, Kaplan, Lakshminarayana, McCormick, Parkin, Phillips, and York.

Graduate Faculty: Associate Members Hoffman, Morris, and Thompson.

Opportunities are available for graduate study in the following areas: low-speed aerodynamics, V/STOL aircraft, turbulence, astrodynamics, turbomachinery, aeroacoustics, plasma dynamics, rarefied gas dynamics, hydrodynamics, stability and control of aerospace vehicles, aeroelasticity, and aerospace structures.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by providing proof of mature and meaningful knowledge in a cultural subject of broad significance as a substitute for one of these languages, or by a comprehensive knowledge of one foreign language.

The entering student must hold a bachelor's degree in physical science, mathematics, or engineering and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if not already completed. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

AEROSPACE ENGINEERING (AERSP)

402. AEROSPACE DESIGN (2)
 404. AEROSPACE ENGINEERING LABORATORY (2)
 405. EXPERIMENTAL METHODS IN AEROSPACE ENGINEERING (3)
 407. AERODYNAMICS OF V/STOL AIRCRAFT (3)
 409. ADVANCED AEROSPACE STRUCTURAL MECHANICS (3)
 410. AEROSPACE PROPULSION (3)
 411. AEROELASTICITY (3)
 412. TURBULENT FLOW (3)
 413. STABILITY AND CONTROL OF AIRCRAFT AND MISSILES (3)
 415. PHYSICAL GAS DYNAMICS (3-6)
 416. INTRODUCTION TO RESEARCH AND DESIGN (1)
 417. AEROSPACE THESIS (2)
 420. PRINCIPLES OF FLIGHT TESTING (3)
 421. (M.E. 421) INTERMEDIATE VISCOUS FLOW (3)
 425. THEORY OF FLIGHT (3)
 430. SPACE PROPULSION AND POWER SYSTEMS (3)
 444. NOISE POLLUTION OF FLUID DYNAMIC ORIGIN (3)
 450. ORBIT AND ATTITUDE CONTROL OF SPACECRAFT (3)
 496. INDEPENDENT STUDIES (1-12)
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503. ELECTROMAGNETICALLY AND CHEMICALLY ACTIVE FLOWS (3) Flow of media which may be conductive, permeable, ionizable, or otherwise capable of interacting with imposed or self-generated fields.
 504. AERODYNAMICS OF V/STOL AIRCRAFT (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aersp. 407.
 505. AERO- AND HYDROELASTICITY (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. CAVITATION (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.
507. THEORY AND DESIGN OF TURBOMACHINERY (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.
508. FOUNDATIONS OF FLUID MECHANICS (3) Mathematical review, fluid properties, kinematics, conservation laws, constitutive relations, similarity principles, the boundary layer, inviscid flow vorticity dynamics, wave motion.
509. DYNAMIC OF IDEAL FLUIDS (3) Irrotational flow theory, two-dimensional and axisymmetric flows, airfoil theory, complex variables, unsteady phenomena; flow with vorticity, finite wing theory. Prerequisite: Aersp. 508.
510. COMPRESSIBLE FLOW (3) Classification and solution of compressible flow problems, high speed gasdynamics, unsteady motion, transonic and hypersonic flows, atmospheric reentry.
511. AERODYNAMICALLY INDUCED NOISE (3) Review of fluid mechanics. General theory of aerodynamic sound. Noise radiation from jets, boundary layers, rotors and fans. Structural response.
512. VISCOUS FLOW (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.
514. STABILITY OF LAMINAR FLOWS (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.
515. FOUNDATIONS OF TURBULENCE (3) The mathematics underlying turbulence theory: descriptions, kinematics of stochastic fields; techniques of solution of linear and some nonlinear problems.
516. HOMOGENEOUS TURBULENCE (3) Dynamics: production, spectral transfer, dissipation, decay of energy; similarity theories.
517. INHOMOGENEOUS TURBULENCE (3) Dynamics: similarity, structural hypotheses; spatial, spectral budget of energy in a number of classical flows.
518. DYNAMICS AND CONTROL OF AEROSPACE VEHICLES (3) Dynamical problems of aircraft and missiles including launch, trajectory, optimization, orbiting, reentry, stability and control, and automatic control. Prerequisite: Aersp. 413 or 450.
550. ASTRODYNAMICS (3) Applications of classical celestial mechanics to space flight planning. Determination and construction of orbital parameters by approximation methods. Perturbation techniques. Prerequisite: Aersp. 450 or Astro. 460 or E.Mch. 410 or Phys. 419.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

AGRICULTURAL ECONOMICS (AG EC)

JOHN W. MALONE, JR., *Head of the Department of Agricultural Economics and Rural Sociology*
6A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Epp, Frey, Gamble, Hallberg, Herrmann, Holt, Hutton, Jansma, Madden, Malone, McAlexander, Partenheimer, Pasto, Schutjer, and Stemberger.

Graduate Faculty: Associate Members Alter, Beierlein, Cordes, Crowley, Daugherty, Dum, Dunn, Fedeler, Fuller, Goode, Haessel, Henson, Smith, Weaver, and Young.

The graduate program emphasizes economic theory and analytical techniques in the fields of farm management, production economics, agricultural marketing, resource economics, rural development,

agricultural policy and prices, and in international agricultural trade and development.

There is no foreign language requirement for the Ph.D. degree; rather, the student must satisfactorily complete courses in economic theory and quantitative methods.

Students entering the M.S. program should have 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either field. Students entering the Ph.D. program should have successfully completed courses in intermediate micro- and macroeconomic theory, in differential and integral calculus and linear algebra, and in introductory statistics. Students are permitted to enter the M.S. and Ph.D. programs with deficiencies but must pass courses to eliminate deficiencies as soon as possible.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. TOEFL scores are required, and Graduate Record Examination scores are optional, for applicants whose first language is not English. All other applicants are required to submit Graduate Record Examination scores.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

Students may qualify for admission to the program in population issues consisting of interdisciplinary course work with special emphasis on the economic, social, and geographic issues arising from the dynamics of population change.

AGRICULTURAL ECONOMICS (AG EC)

407. FARM PLANNING AND FINANCIAL MANAGEMENT (3) *Mr. Fedeler*
410. AGRICULTURAL REAL ESTATE APPRAISAL (3)
420. AGRICULTURAL PRICES (3) *Mr. Stemberger*
421. LAND ECONOMICS (3) *Messrs. Frey and Gamble*
422. LAND AND WATER RESOURCE POLICY (3) *Mr. Alter*
450. INTERNATIONAL AGRICULTURAL TRADE AND DEVELOPMENT (3) *Mr. Schutjer*
460. INDUSTRIAL ORGANIZATION IN FOOD PROCESSING AND DISTRIBUTION (3)
461. DECISION MAKING IN AGRICULTURAL MARKETING FIRMS (3) *Mr. Beierlein*
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. SEMINAR IN AGRICULTURAL ECONOMICS (1-6) Review of current literature and problems.
501. ECONOMICS OF COMMERCIAL AGRICULTURE (3) Application of economic concepts to problems and policies involving agricultural firms, the agricultural industry, and the general agricultural economy. Prerequisite: Econ. 502. *Mr. Fedeler*
502. ECONOMICS OF NATURAL RESOURCES AND RURAL DEVELOPMENT (3) Emphasis will be placed on the application of economic concepts to problems and policies in rural areas. Prerequisites: Econ. 502, 503. *Mr. Goode*
504. SEMINAR IN AGRICULTURAL POLICY (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy making. Prerequisites: Ag.Ec. 420, Econ. 405. Odd years. *Mr. Hallberg*
505. ADVANCED AGRICULTURAL STATISTICS (3) Multiple correlation, curve fitting, analysis of variance, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics. *Mr. Haessel*
507. SEMINAR IN FARM MANAGEMENT (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ. 14. *Mr. Partenheimer*
509. CONCEPTS OF ECONOMETRIC THEORY (3) Concepts underlying the application of econometric methods to economic problems; identification and multiple equation models; hypothesis testing and decision theory. Prerequisites: Econ. 502, 503. *Mr. Hallberg*
514. SURVEY RESEARCH TECHNIQUES IN AGRICULTURAL ECONOMICS (3) Survey methods and

design of samples for obtaining economic data from business-unit and household populations. Prerequisite: Ag. 400. Odd years.

520. FARM PRICE ANALYSIS (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. Even years. *Mr. Hallberg*

524. RESOURCE ECONOMICS (3) Economic aspects of resource use and development: economic growth, land-use planning and control, conservation, resource investment criteria and policies. Prerequisite: Ag.Ec. 421 or 422. *Mr. Epp*

525. RESEARCH METHODS IN RURAL SOCIAL SCIENCES (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences. *Mr. Madden*

527. SEMINAR IN APPLIED QUANTITATIVE METHODS (1-4) *Messrs. Hallberg and Partenheimer*

534. AGRICULTURAL PRODUCTION ECONOMICS (2) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change. Prerequisite: Econ. 502. Even years. *Mr. Partenheimer*

571. SEMINAR IN LAND AND WATER RESOURCE ECONOMICS (3) Critical review of research in resource economics; consideration of special topics in resource use. *Mr. Goode*

596. INDIVIDUAL STUDIES (1-6)

AGRICULTURAL EDUCATION (AG ED)

GENE M. LOVE, *Head of the Department*
102 Armsby Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Curtis, Love, and Stinson.

Graduate Faculty: Associate Members Evans, Heinsohn, Howell, Mortensen, and Williams.

Graduate programs emphasize the professional improvement of teachers and of agricultural extension personnel with education responsibilities. They provide advanced preparation for employment in administration, supervision, teaching including teacher education, and research in agricultural education and related fields. A minor may be taken in an area of agricultural science, technology, or in general studies. Programs may include courses needed for certification in other fields of education. Successful completion of one year of teaching or equivalent professional experience is required prior to completion of the M.S. or M.Ed. degree.

There are no foreign language requirements for the Ph.D. in agricultural education; however, Engl 418 and Sp.Com. 212 or equivalent communication courses are required.

Admission to a doctoral program requires (1) a 3.00 grade-point average for graduate work, (2) a minimum of two years of successful public, private, or extension teaching experience before the degree is completed, (3) evidence of ability to write a scholarly paper or thesis, and (4) a teaching-level competence in English.

Prerequisite for admission to a master's program is a minimum of 18 credits in professional education courses — including educational psychology and student teaching — or certification as a teacher of agriculture or equivalent professional experience. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission to M.S. or M.Ed. programs. The best-qualified applicants for all degrees will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point averages may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL EDUCATION (AG ED)

400v. EDUCATIONAL PROGRAMS IN AGRICULTURE FOR DEVELOPING COUNTRIES (3)

- 418v. SURVEY OF VOCATIONAL EDUCATION IN AGRICULTURE (1-4)
 - 420v. INSTRUCTIONAL MEDIA IN AGRICULTURE (1-6)
 - 422v. SUPERVISION OF VOCATIONAL EDUCATION IN AGRICULTURE (1-4)
 - 424v. OCCUPATIONAL GUIDANCE IN AGRICULTURAL INDUSTRY (1-4)
 - 426v. ADULT EDUCATION IN AGRICULTURE (1-4)
 - 434v. AGRICULTURAL DEVELOPMENTS (1-6)
 - 440. COMMUNICATION METHODS AND MEDIA IN AGRICULTURE (3)
 - 450. METHODOLOGY OF EXTENSION EDUCATION (3)
 - 490, 490v. COLLOQUIUM (1-3)
 - 496, 496v. INDEPENDENT STUDIES (1-12)
 - 497, 497v. SPECIAL TOPICS (1-6)
- 501v. AGRICULTURAL EDUCATION IN THE UNITED STATES (1-3) Historical development, social and philosophical foundations, and current status in relation to the total vocational-technical education program.
- 502v. TEACHING AGRICULTURE (1-3) Vocational education objectives, learning theory, class instruction, cooperative occupational experience, and evaluation.
- 508v. ADMINISTRATION AND SUPERVISION OF AGRICULTURAL EDUCATION (1-3) Administration of state and district systems of vocational-technical education; supervision of teachers of agriculture.
- 509v. TEACHER EDUCATION IN AGRICULTURE (1-6) Organization and administration of university programs of teacher education in agriculture, including preservice preparation, continuing education, research, and other services.
- 520v. SCIENTIFIC METHOD IN THE STUDY OF AGRICULTURAL EDUCATION (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education.
- 521v. SCIENTIFIC METHOD IN THE STUDY OF AGRICULTURAL EDUCATION (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems.
- 524v. PROGRAM DEVELOPMENT IN AGRICULTURAL EDUCATION (1-3) Analysis of occupational needs of students and employment prospects; organization of courses of study and other activities of teachers.
530. AGRICULTURAL COLLEGE TEACHING (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, techniques of teaching, and measurement of results of teaching.
- 590v. COLLOQUIUM (1-3)
- 596, 596v. INDIVIDUAL STUDIES (1-6)
- 597, 597v. SPECIAL TOPICS (1-6)

AGRICULTURAL ENGINEERING (AG E)

HAROLD V. WALTON, *Head of the Department*
250 Agricultural Engineering Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aldrich, Bartlett, Mohsenin, Morrow, Persson, Stephenson, and Walton.

Graduate Faculty: Associate Members DeTar, Hoover, Keppeler, Kjølgaard, and Schroeder.

Graduate programs are available in the areas of physical properties of agricultural materials; plant and animal environmental engineering; agricultural processing and food engineering; agricultural struc-

tures; waste management and systems engineering; agricultural mechanization with emphasis on forage, fruits, vegetables, flowers, and other special crops; soil and water engineering; and energy production and utilization.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by either (1) 9 credits of courses in an approved sequence or (2) a foreign language. Prior approval by the Ph.D. Advisory Committee must be obtained to study a foreign language other than French, German, Russian, or Spanish.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are freeze-drying equipment for drying by sublimation, controlled environmental chambers, plant growth structures for modified atmosphere, a general-purpose analog computer, data processing systems including remote job entry for access to University computer facilities, and laboratories for research on physical properties of agricultural materials. Special equipment is available for physical properties work, including Instron and Ametek testing machines complete with environmental chambers and data acquisition systems, a polariscope for photoelastic stress analysis, triaxial testing equipment, and other unique and specially designed testing facilities. Special facilities outside the Agricultural Engineering Building include a mushroom research and demonstration facility, an anaerobic digester for methane gas generation, and greenhouses designed for solar energy utilization and energy conservation studies.

Prerequisite to major work is the completion of an undergraduate major in engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL ENGINEERING (AG E)

401. FARM MECHANICS FOR TEACHERS OF VOCATIONAL AGRICULTURE (1½-9)
402. FUNCTIONAL DESIGN OF AGRICULTURAL STRUCTURES (3)
403. PHYSICAL PROPERTIES OF AGRICULTURAL MATERIALS (3)
404. AGRICULTURAL MACHINERY (3)
405. AGRICULTURAL PROCESS ENGINEERING (3)
407. SOIL WATER ENGINEERING (3)
408. INSTRUMENTATION FOR AGRICULTURAL PRODUCTION AND PROCESSING (3)
409. AGRICULTURAL SYSTEMS ENGINEERING (3)
410. POWER FOR AGRICULTURAL SYSTEMS (3)
412. PHYSICAL PROCESSES IN FOOD MANUFACTURING I (3)
413. PHYSICAL PROCESSES IN FOOD MANUFACTURING II (3)
414. PHYSICAL PROCESSES IN FOOD MANUFACTURING III (2)
420. SEMINAR (1)
423. PHYSICAL AND RHEOLOGICAL MEASUREMENTS ON BIOMATERIALS (3)
424. FARM MACHINERY MANAGEMENT (3)
457. LAND WASTE DISPOSAL (3)
490. AGRICULTURAL MECHANIZATION SEMINAR (1)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

500. ADVANCED ELECTRO-AGRICULTURE (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.

501. ADVANCED FARM MACHINERY (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.

502. FARM STRUCTURES PROBLEMS (1-6) Analysis of farm structures design problems.

503. PHYSICAL PROPERTIES OF PLANT AND ANIMAL PRODUCTS (3) Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.

- 505. EXPERIMENTAL AND APPLIED INSTRUMENTATION (4) The theory and application of electronics for instrumentation and experimental research.
- 507. PROBLEMS IN SOIL WATER ENGINEERING (1-6) Analysis of engineering problems relating to irrigation, drainage, or erosion control.
- 509. RESEARCH IN AGRICULTURAL ENGINEERING (1-4)
- 520. AGRICULTURAL ENGINEERING SEMINAR (1-3) Reports on research and special topics.
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

AGRONOMY (AGRO)

JAMES L. STARLING, *Head of the Department*
117 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Baker, Bollag, Cleveland, Cunningham, Duich, Fortmann, Harrington, Heald, Hill, Jung, Kendall, Marshall, McKee, Petersen, Starling, Thomas, and Waddington.

Graduate Faculty: Associate Members Baylor, Ciolkosz, Cole, Fox, Fritton, Hall, Hartwig, L. Johnson, M. Johnson, Knievel, Lanyon, Pennock, Pfeifer, Pionke, Risius, Rogowski, Shenk, Stringer, and Watschke.

Students may specialize in soil science, crop science, or soil and crop management. Soil science specialties include genesis and morphology, chemistry, biochemistry, fertility, mineralogy, physics, and remote sensing. Crop science specialties include breeding and genetics, crop quality, crop and weed ecology, and physiology.

The communication and foreign language requirement for the Ph.D. degree may be met either by demonstrating a knowledge of at least one foreign language or by completing at least 6 credits of course work in an area of English communications approved by the student's advisory committee.

Prerequisites for major work in agronomy vary with the area of specialization and the degree sought, but courses in chemistry, mathematics, physics, geology, basic and applied biological sciences, and English communication skills are required. Applicants for the M.S. degree should have a baccalaureate degree including 76 credits of basic and applied natural sciences. For the M.Agr. degree program, an applicant must present a baccalaureate degree in agricultural or forest science. Admission to the Ph.D. program requires an M.S. or equivalent degree, and 100 credits (including credits of the baccalaureate degree) of basic and applied natural sciences. Students who lack some of the prerequisite courses may be admitted but are required to take these courses without degree credit.

A minimum junior-senior grade-point average of 3.00 is required for admission to the agronomy master's degree programs. Exceptions to this minimum may be made for students with special backgrounds, abilities, and interests. Applicants for the Ph.D. program will be evaluated principally on the quality of work completed in previous graduate programs. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

AGRONOMY (AGRO)

- 401. SOIL COMPOSITION AND PHYSICAL PROPERTIES (3) *Messrs. Fritton and Johnson*
- 402. CHEMISTRY OF SOILS AND FERTILIZERS (3) *Mr. Fox*
- 410. CROP SCIENCE (3) *Mr. Knievel*
- 411. BREEDING OF FIELD CROPS (3) *Mr. Cleveland*
- 415. SOIL MORPHOLOGY, MAPPING, AND LAND USE (3) *Mr. Petersen*
- 416. SOIL GENESIS AND CLASSIFICATION (3) *Mr. Ciolkosz*
- 417. FOREST SOILS (3) *Mr. Pennock*
- 419. SOIL PROPERTIES (4) *Mr. Baker*
- 420. AGRONOMIC CASE STUDIES IN SOIL, PLANT, AND WATER MANAGEMENT (3)
- 422. CONSERVATION OF SOIL AND WATER RESOURCES (3) *Mr. Cunningham*

423. FORAGE CROP MANAGEMENT (3) *Mr. Baylor*
425. FIELD CROP MANAGEMENT (3) *Mr. Pfeifer*
438. PRINCIPLES OF WEED CONTROL (3) *Mr. Hartwig*
497. SPECIAL TOPICS (1-6)
501. SOIL FERTILITY (3) Soil-plant relations emphasizing recent concepts of ion accumulation by plants as affected by soil conditions and plant physiology. Prerequisites: Agro. 402, Biol. 441. *Mr. Hall.*
506. SOIL PHYSICAL CHEMISTRY (4) Colloidal chemistry of soils emphasizing ion adsorption, double-layer theory, diffusion, and water properties. Prerequisites: Agro. 419; Bioch. 425 or Chem. 451. *Mr. Baker*
507. SOIL PHYSICS (3-4) Soil physical properties emphasizing water, heat, gas, and ion movement in unsaturated soils. Laboratory included with 4 credits. Prerequisites: 6 credits each of calculus, physics, and soils. *Mr. Fritton*
509. METHODS OF GENETIC ANALYSIS (3) Methods of qualitative genetics. Tests of hypotheses, homogeneity, linkage detection, calculations of recombination values, monosomic analysis, and tetrasomic inheritance. Prerequisite: 6 credits of genetics or plant breeding. *Mr. Cleveland*
510. CYTOGENETICS IN PLANT BREEDING (3) Chromosomal heredity of agricultural plants. Chromosome morphology; cytogenetic behavior of aneuploids, haploids, auto- and allopolyploids, and interspecific hybrids. Prerequisite: 6 credits of genetics including 3 credits of cytogenetics or cytology. *Mr. Cleveland*
511. BIOMETRICAL PLANT BREEDING (3) Quantitative genetics of plant populations; applications to breeding methodology and selection. Prerequisites: Agro. 512 and 3 credits of plant breeding. *Messrs. Hill and Risius*
512. FIELD PLOT TECHNIQUE (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Ag. 400 or Stat. 200. *Mr. Risius*
515. NUTRITIVE VALUE OF CROP PLANTS (3) Biochemical, physiological, genetic, and morphological nature of crop plants related to animal response. Laboratory includes nutritive evaluation procedures. Prerequisites: 3 credits of crop production and 6 credits of biochemistry and/or nutrition. *Mr. Shenk*
517. CROP ECOLOGY AND PHYSIOLOGY (3) Ecological and physiological factors affecting the productivity of crop plants. Prerequisite: Agro. 410. *Mr. McKee*
518. RESPONSES OF CROP PLANTS TO ENVIRONMENTAL STRESS (3) Physiological and ecological aspects of the response of crop plants to environmental stresses in establishment, persistence, and reproduction. Prerequisite: Agro. 410. *Mr. McKee*
519. NATURE OF SOIL MINERALS (3) Constituent minerals of soils: modern methods for identification; relations to soil formation and agricultural practices. Prerequisite: Agro. 401. *Mr. Johnson*
545. THE APPLICATION OF STATISTICS TO FIELD EXPERIMENTS (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. *Messrs. Risius and Shenk*
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

AMERICAN STUDIES (AM ST)

IRWIN RICHMAN, *In Charge of the Graduate Program in American Studies*
The Capitol Campus, Middletown, PA 17057

Degree Conferred: M.A.

Graduate Faculty: Senior Members Lear, Richman, Tischler, and Wolf.

Graduate Faculty: Associate Members R. Graham, T. Graham, Milspaw, Molovinsky, and Patterson.

This program emphasizes the study of American society as a whole, not as interpreted by a single discipline, but in the larger context of a culture. The purpose of the program is to provide the student with the opportunity to acquire knowledge and understanding within any of the following areas: ethnic composition and demographic problems of the American people; regional characteristics; the technological base of American civilization; economic, political, and social institutions; the media of communication; artistic expression, particularly in art, architecture, literature, and music; philosophy and values; and the dynamics and interrelationships of all of these.

The student is required to take a minimum of 30 credits, including at least 18 credits in the 500 series. A maximum of 24 of these 30 credits shall be taken within the program area. An original, scholarly master's paper or creative production initiated by the student, supervised by an appropriate professor, and judged by a committee is required. One to 6 credits can be accumulated during work on the master's production.

For admission to the master's program, a student must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. Social sciences and the humanities are not required as prerequisites, though it is anticipated that students will have had work in these areas. The application, transcripts, and a letter outlining personal goals and reasons for applying for the program should be sent directly to the Graduate Office, The Capitol Campus, Middletown, PA 17057.

REQUIRED COURSES

AM.ST. 500. THEORY AND METHODS (3) Study of the methods and materials of American Studies scholarship, compilation of bibliographies, the writing of scholarly papers, and proper documentation.

AM.ST. 580. PRODUCTION IN AMERICAN STUDIES (1-6) An original and independent exploration of some area of American Studies.

APPROPRIATE COURSES may be taken from the following list and from 500-level courses in other fields with the concurrence of the student's adviser.

AM.ST. 511. PIVOTAL BOOKS (3-9) Exploration of a number of books which have been particularly influential in shaping thinking about American civilization.

AM.ST. 530. TOPICS IN AMERICAN FOLKLORE (3) A detailed exploration of aspects of folklore and folklife in America.

AM.ST. 533. AMERICAN CIVILIZATION IN THE EIGHTEENTH CENTURY (3-9) Detailed investigation of specific topics in eighteenth-century American civilization.

AM.ST. 534. AMERICAN CIVILIZATION IN THE NINETEENTH CENTURY (3-9) Representative interdisciplinary investigation of social, historical, economic, and aesthetic forces predominant in nineteenth-century America.

AM.ST. 535. AMERICAN CIVILIZATION IN THE TWENTIETH CENTURY (3-9) Detailed investigation of specific periods or topics in twentieth-century American civilization.

AM.ST. 570. TOPICS IN AMERICAN ART (1-6) Various themes within the American arts will be explored under this rubric.

AM.ST. 590. COLLOQUIUM (1-3)

AM.ST. 596. INDIVIDUAL STUDIES (1-6)

AM.ST. 597. SPECIAL TOPICS (1-6)

ADDITIONAL COURSES may be taken from the following list and from 400-level courses in other fields with the concurrence of the student's adviser.*

- AM.St. 400. AMERICAN COLONIAL EXPERIENCE
- AM.St. 401. AMERICAN REVOLUTION AND EARLY NATIONAL EXPERIENCE
- AM.St. 422. WESTERN MOVEMENT
- AM.St. 431. THE AMERICAN CHARACTER
- AM.St. 442. AMERICAN FOLKLORE
- AM.St. 445. AMERICAN PHILOSOPHY
- AM.St. 451. CIVIL WAR AND RECONSTRUCTION
- AM.St. 452. THE AMERICAN RENAISSANCE
- AM.St. 453. THE GILDED AGE AND THE PROGRESSIVE IMPULSE
- AM.St. 454. AMERICA'S POLITICAL PARTIES
- AM.St. 456. MASS CULTURE: THE POPULAR ARTS IN AMERICA
- AM.St. 457. IMMIGRANTS AND AMERICANS
- AM.St. 458. CONTEMPORARY AMERICA
- AM.St. 459. AMERICA'S COMING OF AGE 1914-1939
- AM.St. 460. AMERICAN ART AND ARCHITECTURE
- AM.St. 463. AMERICAN MUSIC
- AM.St. 469. AMERICAN INDIAN ETHNOLOGY
- AM.St. 470. REGIONALISM IN AMERICA
- AM.St. 474. (Econ. 474) AMERICAN ECONOMIC DEVELOPMENT
- AM.St. 475. THE AMERICAN IMPACT ABROAD
- AM.St. 476. INTERACTION — CANADA AND THE UNITED STATES (3)
- AM.St. 479. UNITED STATES DIPLOMATIC HISTORY
- AM.St. 480. MUSEUMS AND CULTURE
- AM.St. 491. SEMINAR IN AMERICAN CULTURE
- AM.St. 496. INDEPENDENT STUDIES (1-12)
- AM.St. 497. SPECIAL TOPICS (1-6)
- So.Sc. 403. CONTEMPORARY U.S. FOREIGN POLICY
- So.Sc. 470. THE PRESIDENCY AND THE EXECUTIVE PROCESS

ANATOMY (ANAT)

BRYCE L. MUNGER, *Chairman of the Department*
The Milton S. Hershey Medical Center
Hershey, PA 17033

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baird, Munger, Pubols, and Zagon.

Graduate Faculty: Associate Members Leure-duPree, McCallister, and Page.

The graduate program emphasizes the general areas of gross anatomy, histology/cytology, neuroanatomy/neurophysiology, or appropriate combinations of these areas. Approaches offered include morphological (descriptive, comparative, developmental), functional (physiological, chemical), and experimental. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants must

*Descriptions of these courses may be found in *The Capitol Campus Catalog*.

provide complete transcripts and two letters of recommendation. Scores from the Graduate Record Examination and a personal interview are desirable.

This program is offered only at The Milton S. Hershey Medical Center.

ANATOMY (ANAT)

501. FUNDAMENTALS OF GROSS ANATOMY I (3) Macroscopic structure of the upper extremity, head, and neck, with emphasis on normal organization, functional correlations, and clinical significance.

502. FUNDAMENTALS OF GROSS ANATOMY II (3) Macroscopic structure of the thorax, abdomen, pelvis, and lower extremity, with emphasis on normal organization, functional correlations, and clinical significance. Prerequisite: Anat. 501.

505. MICROSCOPIC ANATOMY (4) Microscopic organization of tissues and cells; interrelationships of cells; chemical and functional specializations of cells.

510. NEUROBIOLOGY (3) Morphology and function of the sense organs, general organization of the brain, and physiological studies of central nervous system function.

512. HUMAN EMBRYOLOGY (2) A basic study of the development of the human embryo including gamete production and fusion, implantation, and organogenesis.

513. COMPARATIVE MORPHOGENESIS (3) A descriptive and experimental study of vertebrate and invertebrate development.

515. DEVELOPMENTAL NEUROBIOLOGY (2) Development of the nervous system in all aspects.

530. DISSECTION (2-4) Intensive laboratory study of selected regions of the human body. Coverage and credit arranged by consultation.

535. SUBMICROSCOPIC ANATOMY (3) Current literature on molecular and micellar organization of cells and tissues in diverse systems; application of interference and electron microscopy. Prerequisite: Anat. 505.

542. COMPARATIVE NEUROLOGY (3) Topics in functional anatomy and neurophysiology. The comparative approach to the organization of the mammalian nervous system will be stressed. Prerequisite: Anat. 510.

543. SENSORY PROCESSES (3) Morphological, physiological, and psychophysical aspects of mammalian sensory systems; emphasizing somatic sensory, visual, and auditory systems. May be repeated. Prerequisite: Anat. 510.

545. COMPARATIVE AUDITORY AND VISUAL ANATOMY (3-5) An introduction to the morphology and evolution of the vertebrate eye and ear; individualized laboratory work arranged by consultation.

550. SEMINAR IN QUANTITATIVE OPTICS (3) Study of the various types of light microscopy instruments and application of these tools to quantitative measurements in biological systems. Prerequisite: Anat. 505.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

ANIMAL INDUSTRY (A I)

B. R. BAUMGARDT, *Head of the Department of Dairy and Animal Science*
325 Animal Industries Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Baumgardt, Cowan, Hershberger, Long, Martin, Sherritt, Sink, Wangsness, Wilson, and Ziegler.

Graduate Faculty: Associate Members Cash, King, and Merritt.

Opportunities are available for graduate study and research in breeding and genetics, nutrition and feed technology, physiology, animal management systems, growth and body composition, and meat science. Ruminant, nonruminant, small animal, and wildlife species are available.

The M.Agr. is a professional program designed to prepare individuals for specialist and management positions in county agricultural extension, government, or industry and does not require a thesis. The academic M.S. and Ph.D. programs require a thesis and are designed for those primarily interested in education and research. The requirements of these programs are detailed in the departmental publication, *Requirements of the Graduate Programs in Animal Industry*. The communication and foreign language requirements for the Ph.D. degree may be satisfied by competence in either one foreign language or communications skills.

For admission the student must complete an undergraduate major in animal science or a closely related field. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without graduate degree credit. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

ANIMAL INDUSTRY (A I)

- 405. MEAT ANIMAL MANAGEMENT (4)
- 406. SWINE MANAGEMENT AND PRODUCTION (3)
- 407. ADVANCED HORSE PRODUCTION AND MANAGEMENT (2)
- 408. SHEEP PRODUCTION AND MANAGEMENT (3)
- 409. BEEF PRODUCTION AND MANAGEMENT (3)
- 423. ADVANCED LIVESTOCK SELECTION (2)
- 424. ANIMAL INDUSTRY SEMINAR (1 per term)
- 431. ADVANCED MEAT SELECTION AND GRADING (2)
- 497. SPECIAL TOPICS (1-6)

501. PEDIGREE STUDY (1-6) Research work in breed study history, and analytical study of breed pedigrees, and a complete survey of the herd, flock, or stud book.

505. ADVANCED ANIMAL BREEDING (1-5) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: An.Sc. 322.

510. ANIMAL SCIENCE RESEARCH METHODS (3) Application of scientific method; experimental design and procedures; analyzing, interpreting, and reporting research results. Prerequisite: Ag. 400.

514. ANIMAL GROWTH AND DEVELOPMENT (3) Animal life cycles; nature of growth and development; effects of biological, environmental, social, and psychological variants; homeostasis and organismic theory. Prerequisites: 3 credits in biochemistry and 3 credits in physiology.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

NOTE: See *Animal Nutrition, Physiology, and Food Science*. Also see *Animal Science* under "Other Graduate Courses."

ANIMAL NUTRITION (A NTR)

ROY J. MARTIN, Jr., *Chairman of the Committee on Animal Nutrition*
301 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baumgardt, Cowan, Hartsook, Hershberger, Kesler, Leach, Long, Martin, McCarthy, Mendez, Muller, Scholz, and Wangsness.

Graduate Faculty: Associate Member Shellenberger.

This is an interdepartmental graduate program designed to enable students to obtain thorough training in animal nutrition. The program is under the direction of a committee composed of graduate faculty members of the Departments of Animal Science, Dairy Science, Poultry Science, and Veterinary Science, and the Human Performance Research Laboratory. Programs are offered in ruminant and nonruminant nutrition, including: physiology of nutrition; nutritional requirements for productive functions; metabolism of carbohydrates, lipids, proteins, vitamins, and minerals; and regulation of food intake and other metabolic functions.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages.

Undergraduate preparation should include organic and analytical chemistry, physics, biology, and mathematics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiencies without graduate credit.

Students should have an appropriate background and a 3.00 average in the major area and in related sciences for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum requirements may be made for students with special backgrounds, abilities, and interests.

The following nutrition courses are offered by participating departments, and their descriptions may be found under the listings of the respective departments: D.Sc. 511, Pty.Sc. 502, and V.Sc. 535. Courses related to animal nutrition can be found under the following listings in this bulletin: Animal Industry, Biochemistry, Dairy Science, Food Science, Physiology, Poultry Science, and Veterinary Science. For other graduate courses in this subject area see courses listed under Nutrition such as Nutr. 552, 556, and 557.

ANIMAL NUTRITION (A NTR)

400. NUTRITION AND FEED TECHNOLOGY (3)

401. PHYSIOLOGY OF NUTRITION (3)

501. ENERGY METABOLISM (2) Integration of biochemical and physiological processes in energy metabolism; concepts underlying the application of bioenergetics and calorimetry to body functions. Prerequisites: 3 credits each in biochemistry and physiology.

503. MICRONUTRIENTS: NUTRITION, METABOLISM, AND FUNCTION (2) Functional approach to the study of vitamins and trace elements in the nutrition and metabolism of animals and man. Prerequisites: 3 credits each in biochemistry, nutrition, and physiology.

505. RUMINOLOGY (3) Physiological, biochemical, and microbiological activities occurring within the rumen and the relation of rumen function to animal response. Prerequisites: at least one course in each of the following areas: animal nutrition, physiology, microbiology, and biochemistry.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

ANTHROPOLOGY (ANTHY)

WARREN T. MORRILL, *Head of the Department*
409 Carpenter Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Baker, Chagnon, Escobar, Hunt, Michels, Morrill, and Sanders.

Graduate Faculty: Associate Members Dyke, Eckhardt, Hatch, Kurland, Nydegger, and Webster.

The master's program is designed to train students in general anthropology. The doctoral program is structured to train students in the following areas of specialization: social anthropology, cultural evolution and ecology, analytic archaeology, archaeological technology, archaeology culture areas, or human biology including human physiology, adaptability, biological determinants of human behavior, demography, and human evolution.

M.A. candidates may submit either a thesis or a term paper. If the latter is chosen, 6 credits in 500-level courses in the major field must be scheduled in lieu of thesis credits. The M.A. degree may be bypassed by exceptional candidates for the Ph.D. degree.

The communication and foreign language requirement for the Ph.D. degree includes a reading knowledge of a foreign language plus an option from among additional foreign languages, field languages, linguistics, and statistics.

Undergraduate preparation must include 12 credits in anthropology and archaeology or their equivalent. A student with an excellent record but who does not meet these requirements may be admitted provided course deficiencies are made up without graduate credit. Students with a 3.00 or higher junior-senior average and with appropriate course backgrounds who have research interests directly related to the special anthropological competences within the department will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ANTHROPOLOGY (ANTHY)

400. HUMAN EVOLUTION: THEORY AND PROCESS (3)
401. HUMAN EVOLUTION: THE MATERIAL EVIDENCE (3)
402. HUMAN ECOLOGY (3)
405. PRIMATOLOGY (3)
408. DEMOGRAPHIC METHODS IN ANTHROPOLOGY (3)
409. ANALYTIC METHODS LABORATORY (1)
414. SYSTEMATIC INSTRUCTION IN ANTHROPOLOGY (3)
415. (C.F.Ed. 415) ANTHROPOLOGY OF EDUCATION (3)
420. ARCHAEOLOGY OF THE NEAR EAST (3)
421. ARCHAEOLOGY OF THE CENTRAL ANDES (3)
422. ARCHAEOLOGY OF MESO-AMERICA (3)
423. ARCHAEOLOGY OF EASTERN UNITED STATES (3)
424. ARCHAEOLOGY OF AFRICA (3)
440. SOUTH AMERICAN TRIBAL SOCIETIES (3)
441. ETHNOLOGY OF THE ANDEAN REGION (3)
442. EUROPEAN PEASANTRY (3)
444. ETHNOLOGY OF MESO-AMERICA (3)
446. ETHNOLOGY OF NORTH AMERICA (3)
447. ETHNOLOGY OF SUB-SAHARAN AFRICA (3)
448. ETHNOLOGY OF THE MIDDLE EAST (3)
449. ETHNOLOGY OF SOUTHEAST ASIA (3)
450. COMPARATIVE SOCIAL ORGANIZATION (3)
451. ECONOMIC ANTHROPOLOGY (3)
453. (Soc. 453) PRIMITIVE RELIGION (3)

454. POLITICAL ANTHROPOLOGY (3)
 455. CULTURE AND PERSONALITY (3)
 456. CULTURAL ECOLOGY (3)
 457. LANGUAGE IN CULTURE (3)
 458. PRIMATE SOCIOBIOLOGY (3)
 460. ANTHROPOLOGICAL THEORY (3)
 461. METHODS IN CULTURAL ANTHROPOLOGY (3)
 462. METHODS IN ARCHAEOLOGY (3)
 463. FIELD LINGUISTICS (3)
 464. TRIBAL SOCIETIES (3)
 471. HISTORY OF ANTHROPOLOGICAL THEORY (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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500. HUMAN EVOLUTION (3) Theoretical problems in analysis of human evolution. Prerequisite: one course in human genetics or physical anthropology.
 501. EVOLUTION OF HUMAN BEHAVIOR (3) The application of evolutionary theory to the study of man's structure, function, and culture. Prerequisites: Anthy. 21 or 401, and 3 additional credits in anthropology, sociology, or psychology.
 502. HUMAN ECOLOGY THEORY (3) Analysis of interaction of physical, biological, and cultural factors in human adaptation. Prerequisite: 3 credits in physical anthropology.
 504. SOCIAL AND CULTURAL CHANGE (3) Theories and methods used in the analysis of social and cultural change.
 505. TOPICS IN PRIMATE SOCIOBIOLOGY (3) An advanced seminar on current research and problems in the study of nonhuman primate behavior and ecology. Prerequisite: Anthy. 458.
 506. CULTURAL DYNAMICS (3) Survey of the major theories of culture change with special reference to archaeological research.
 507. THE BIOLOGY OF HUMAN ADAPTABILITY (3) An exploration of the biological mechanisms which aid man's survival in a variety of environmental settings.
 508. RESEARCH PROBLEMS IN CULTURE HISTORY (3-9)
 509. SEMINAR IN REGIONAL STUDIES (3-9) Research and analysis in selected world cultural areas, including ecology, prehistory, history, ethnography, and current status.
 510. WORLD ETHNOGRAPHIC SURVEY (3) General survey of world cultures and their historical development.
 511. (Hl.Ed. 511) HEALTH IMPLICATIONS IN THE GROWTH AND DEVELOPMENT OF SCHOOL CHILDREN (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems.
 513. (Hl.Ed. 513) HEALTH IMPLICATIONS IN MATURITY AND AGING (3) Changes in the human body in maturity and aging; mechanisms of physiologic aging; implications for health and preventive medicine. Prerequisite: Hl.Ed. 511.
 - 522-523. ECOLOGICAL THEORY IN ANTHROPOLOGY (3 each) Man's biology, culture history, and culture variation from the ecological perspective. Two-term enrollment required. Prerequisite: 6 credits in anthropology.
 530. INDIVIDUAL READINGS IN ANTHROPOLOGY (1-6) Reading or research in selected aspects of general anthropology.
 531. INDIVIDUAL RESEARCH IN ANTHROPOLOGY (3-12)
 545. SEMINAR IN ANTHROPOLOGY (1-9) Critical analysis of research in selected areas of anthropology.
 558. EVOLUTION OF SOCIAL STRUCTURES I (3) Evolution of social organization. Biological and social changes differentiating human and primate societies.

- 559. EVOLUTION OF STRUCTURES II (3) Major anthropological approaches to study of social organization.
- 560. ANTHROPOLOGICAL THEORY (3) Theory used in culture — historical, sociological, and psychological interpretations.
- 561. FIELD METHODS IN ANTHROPOLOGY (3-9) Individual field work in any aspect of anthropology, supervised by staff of professional rank.
- 562. LABORATORY METHODS IN ANTHROPOLOGY (3-9) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.
- 563. SEMINAR IN LINGUISTIC ANTHROPOLOGY (3-6) Organized research on special topics in linguistic anthropology.
- 597. SPECIAL TOPICS (1-6)

ARCHITECTURAL ENGINEERING (A E)

GIFFORD H. ALBRIGHT, *Head of the Department*
101 Engineering A Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members McLaughlin and Tichy.

Graduate Faculty: Associate Members Albright, Flynn, Geschwindner, Gilman, Summers, and Wheeler.

Students may specialize in structural analysis and design, environmental control engineering (including energy conservation and energy management in building), solar energy applications, illumination, acoustics, materials of construction, building construction management, computer application to building design and performance, or nuclear defensive and protective construction. The latter area includes shelter planning, effects of nuclear weapons, shelter environmental requirements, analysis and design of blast-resistant structural systems, and integrated engineering requirement for protective construction.

For admission a student must have a strong background in some field of engineering; in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURAL ENGINEERING (A E)

- 401. ARCHITECTURAL ENGINEERING (3)
- 402. ARCHITECTURAL ENGINEERING (3)
- 403. ARCHITECTURAL ENGINEERING (3)
- 430. ARCHITECTURAL ENGINEERING (3)
- 431. ARCHITECTURAL ENGINEERING (3)
- 439. ARCHITECTURAL ENGINEERING (3)
- 441. INTEGRATION OF ARCHITECTURAL ENGINEERING SYSTEMS (3)
- 454. ENVIRONMENTAL ENGINEERING IN BUILDINGS — DESIGN (3)
- 458. ADVANCED ARCHITECTURAL ACOUSTICS AND NOISE CONTROL (3)
- 464. ADVANCED ARCHITECTURAL ILLUMINATION SYSTEMS DESIGN (3)
- 471. BUILDING CONSTRUCTION ASSEMBLIES (3)
- 472. BUILDING CONSTRUCTION MANAGEMENT I (3)
- 473. BUILDING CONSTRUCTION MANAGEMENT II (3)
- 474. BUILDING COST ANALYSIS (3)
- 475. BUILDING CONSTRUCTION ENGINEERING I (3)

- 476. BUILDING CONSTRUCTION ENGINEERING II (3)
- 477. BUILDING PROJECT ANALYSIS (3)
- 481. ARCHITECTURAL ENGINEERING THESIS (2)
- 482. ARCHITECTURAL ENGINEERING THESIS (2)
- 483. ARCHITECTURAL ENGINEERING THESIS (2)
- 486. PROFESSIONAL ENGINEERING PRACTICE (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 542. ADVANCED PROBLEMS AND RESEARCH IN ARCHITECTURAL ENGINEERING (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems.
- 545. ARCHITECTURAL ENGINEERING SEMINAR (1-6) Current literature and special problems in architectural engineering; presentation of technical papers.
- 553. SELECTED PROBLEMS IN NUCLEAR DEFENSE RESEARCH (1-6)

ARCHITECTURE (ARCH)

RANIERO CORBELLETTI, *Head of the Department*
308 Sackett Building

Degrees Conferred: M.S., M.Arch.

Graduate Faculty: Senior Members Corbelletti, Golany, and Strumillo.

Graduate Faculty: Associate Members Anderson, Hallock, Inserra, and Vollmer.

The Master of Science is an academic degree available to students with training in other design-related fields, as well as to students with a professional degree in architecture reentering the University for study in a specialty. Advanced studies are offered in architecture, urban design, and planning. The student is offered opportunity for independent research and extensive interdisciplinary work under the guidance of specialists and scholars in technical, cultural, industrial, and social fields. The nonthesis option is available for the M.S. degree.

The Master of Architecture degree program is planned to provide the depth and breadth of knowledge needed to enter the architectural profession and become licensed as a professional architect after the required period of internship. Requirements for admission include the equivalent of 39 credits in design-research work and a statement of purpose concerning the professional aims of the candidate. A portfolio of examples of the student's work must be presented. The nonthesis option is available for the M.Arch. degree. The program is available to candidates holding a B.A. or B.S. degree with a major in architecture, environmental design, or a nonprofessional Bachelor of Architecture degree.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURE (ARCH)

- 430. DESIGN-RESEARCH II (4-12)
- 441. ARCHITECTURAL DESIGN ANALYSIS (3)
- 442. ARCHITECTURAL DESIGN ANALYSIS (3)
- 443. ARCHITECTURAL DESIGN ANALYSIS (3)
- 461. ARCHITECTURAL STRUCTURAL SYSTEMS I (3)
- 462. ARCHITECTURAL STRUCTURAL SYSTEMS II (3)
- 463. ARCHITECTURAL STRUCTURAL SYSTEMS III (3)
- 465. ARCHITECTURAL BUILDING MATERIALS (3)
- 471. ENVIRONMENTAL CONTROL SYSTEMS I (3)
- 472. ENVIRONMENTAL CONTROL SYSTEMS II (3)

- 481. ADVANCED ARCHITECTURAL DATA SYSTEMS I (3)
- 482. ADVANCED ARCHITECTURAL DATA SYSTEMS II (3)
- 483. SPECIAL PROBLEMS — ARCHITECTURAL DATA SYSTEMS APPLICATIONS (3)
- 497. SPECIAL TOPICS (1-6)

- 515. NEW TOWNS PLANNING SEMINAR (3) Examination of the process, concepts, and structure of new towns planning as a response to contemporary urban-regional development problems.
- 516. NEW COMMUNITIES SEMINAR (3) Examination and evaluation of the new communities movement in the United States.
- 517. NEW TOWNS PLANNING PROCESS (3) A systematic study and analysis of the sequence of actions in the new towns planning process.
- 518. NEW TOWNS RESEARCH SEMINAR (3) Advanced research seminar using comparative case studies of comprehensive contemporary issues of new towns planning. Prerequisites: Arch. 515, 517.
- 530. ARCHITECTURE I (4-12) Problems in architectural planning and design. Programming and/or implementation methodologies and applications for various environmental design scales.
- 531. ARCHITECTURE II (4-12) Continuation of Arch. 530 with concentration and specialization options. Prerequisite: Arch. 530.
- 532. COMPREHENSIVE PLANNING PROCESS STUDIO (4-12) Field case studies in analysis forecasting and projections of urban physical design elements. Preparation of comprehensive plan, regulations, and implementation.
- 535. NEW TOWNS PLANNING STUDIO (4-12) A team workshop of planning and design of new towns, involving data gathering, surveys, analysis, projection, and implementation.
- 591. ARCHITECTURAL RESEARCH (2-12) Guided research project.

ART (ART)

LAWRENCE F. EDWARDS, *Head of the Department*
102 Visual Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Members Adams, Cook, Edwards, McCoy, and Zoretich.

Graduate Faculty: Associate Members DonTigny, Frost, Hessel, Lang, McHale, Porter, Shobaken, Sommese, and Stephenson.

The M.A. program is planned to provide a broad range of experience and study in the visual arts. A thesis in an area of specialization is required. Requirements for admission include a broad undergraduate training in art and the presentation of a portfolio of the applicant's work.

The M.F.A. program is planned to provide professional emphasis in a specific area of art. A creative project and supporting monograph are required. Requirements for admission include 36 credits in studio art with some indication of concentration in a chosen area and a statement of purpose concerning the professional aims of the candidate. A portfolio must be presented.

A portfolio of slides (quality photographs for sculpture applicants), rather than actual work, is requested. A selection of no fewer than twenty examples should be presented. The majority of these should be in the area of the applicant's interest, but the portfolio should also include a lesser emphasis in related areas.

All students accepted for graduate study in art who lack the adequate undergraduate courses or show deficiencies in some area will be required to take additional course work without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ART (ART)

- 411. SEMINAR IN CONTEMPORARY ART (3 per term, maximum of 6)
- 421. ADVANCED DRAWING (3 per term, maximum of 9)
- 425. DRAWING SEMINAR (3 per term, maximum of 6)
- 430. ADVANCED SCULPTURE (3 per term, maximum of 12)
- 448. ADVANCED PRINTMAKING (3 per term, maximum of 12)
- 450. ADVANCED PAINTING (3 per term, maximum of 12)
- 455. ADVANCED PAINTING CRITIQUE (3 per term, maximum of 6)
- 460. ADVANCED WATERCOLOR (3 per term, maximum of 12)
- 465. ADVANCED DESIGN (3 per term, maximum of 9)
- 470. TIME AND SEQUENCE (3)
- 471-472. SENIOR PROBLEMS (3 each)
- 473. GRAPHIC DESIGN SEMINAR (3)
- 480. ADVANCED CERAMIC ARTS (3 per term, maximum of 12)
- 491. PHOTOGRAPHY AND OTHER DISCIPLINES (3 per term, maximum of 12)
- 494. GROUP PROJECTS IN PHOTOGRAPHY (3 per term, maximum of 9)
- 495. CREATIVE PROJECTS IN PHOTOGRAPHY (3 per term, maximum of 12)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. ART RESEARCH (2-6) Original study and practice in art relating to material, concept, or technique.
- 530. ADVANCED SCULPTURE (3-12) Individual projects in sculpture leading to the development of a collection or body of work representative of the artist.
- 545. PRINTMAKING (2-12) Problems in printmaking leading to the development of a collection or body of work representative of the individual artist.
- 550. PAINTING (2-12) Individual problems in painting leading to the development of a collection or body of work representative of the artist.
- 570. DESIGN (2-12) Individual projects in design with special emphasis on professional practice in specialized fields of graphic design.
- 580. CERAMICS (2-12) Experimental problems in ceramics leading to the development of a collection or body of work representative of the individual.
- 595. PHOTOGRAPHY (3) Individual projects in photography leading to the development of a body of specialized work representative of the artist. Prerequisite: 12 credits of Art 495.

ART EDUCATION (A ED)

HARLAN E. HOFFA, *Head of the Division of Art and Music Education*
269 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Beittel, Bradley, Hoffa, Schwartz, Van Dommelen, and Wilson.

Graduate Faculty: Associate Members Anderson, Chomicky, and Ott.

This program prepares students for careers in public school art teaching, art supervision, college teaching, administration, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include work in art studio, art history, art education, education, educational psychology, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctoral degree. A foreign language is not required of all Ph.D. degree candidates. In lieu of a foreign language, students

will include a series of research and communications studies pertinent to their interests and to their graduate programs and may include a foreign language approved by the doctoral committee.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Transcripts should indicate high attainment in appropriate academic and creative work, and recommendations should attest to scholarship and ability to work independently. Creative work, as shown by slides and photographs, should show a high level of involvement and sensitivity to aesthetic-forming processes.

Students who seek admission to the graduate program must make formal application to the admissions committee of the art education program.

ART EDUCATION (A ED)

- 404. METHODS OF GRAPHICS AND ILLUSTRATIONS (3)
- 414. ADVANCED CRAFTS FOR TEACHERS (3-6)
- 415. FIBER CRAFTS IN EDUCATION (3)
- 417. METAL CRAFTS IN EDUCATION (3)
- 420. CERAMICS FOR TEACHERS (3)
- 434. ART APPRECIATION IN THE EDUCATIONAL PROGRAM (3)
- 435. ART IN THE ELEMENTARY SCHOOL (3)
- 436. ART IN THE SECONDARY SCHOOL (3)
- 437. PROFESSIONAL TERM IN ART EDUCATION (10)
- 486. CURRENT PROBLEMS IN ART EDUCATION (2-3)
- 487. MURAL PAINTING IN SCHOOLS (3)
- 488. ADVANCED MURAL PAINTING IN SCHOOLS (3)
- 489. ART EXPERIENCES WITH CHILDREN (3)
- 490. INTRODUCTION TO RESEARCH IN ART EDUCATION (3)
- 494. SCHOOLS AND MUSEUMS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. SEMINAR IN ART EDUCATION (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.
- 504. ADVANCED METHOD IN GRAPHIC PROCESSES (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.
- 514. FUNCTIONAL RELATIONSHIPS IN CRAFTS (3) Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisite: 6 credits in crafts, or 3 in design and 3 in advanced crafts.
- 516. ANALYSIS OF THREE-DIMENSIONAL PROCESSES IN ART (3) Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.
- 520. ADVANCED CERAMIC ART (3) Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A.Ed. 420.
- 535. ADMINISTRATION AND SUPERVISION OF ART EDUCATION PROGRAMS (3) The problems and responsibilities of the city, county, and state art supervisor; curriculum, facilities, financing, supervision, in-service training, and reporting. Prerequisites: A.Ed. 435, 436.
- 536. CURRICULUM DEVELOPMENT IN ART EDUCATION (3) Factors affecting art curriculum decisions, analysis, selection, organization, preparation of curriculum. Evaluation and sources of art curriculum improvement and innovation. Prerequisite: 6 credits of methods.
- 541. THEORIES OF CHILD ART (3) Study of current theories of child art; application of recent psychological and anthropological theories to understanding child art. Prerequisite: A.Ed. 486 or 501.
- 545. EVALUATION AND ASSESSMENT IN ART EDUCATION (3) Study of theories of evaluation; application of judgmental criteria; analysis and construction of assessment instruments and scoring procedures. Prerequisites: A.Ed. 490, 501.

588. **HISTORY OF ART EDUCATION (3)** Historical development of philosophies in art education in the United States and abroad.
589. **RESEARCH METHODS IN ART EDUCATION (3-6)** Orientation in research methods; findings and designs related to the study of problems in art education.
595. **RESEARCH IN ART EDUCATION (1-6)** Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisite: 15 credits in art education at the 400 and 500 levels, including A.Ed. 589.

ART HISTORY (ART H)

HELLMUT W. HAGER, *Head of the Department*
229 Arts II Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Battisti, Chenault Porter, Cutler, Davezac, Fleischer, Hager, Henisch, Kiang, and Mauner.

Graduate work is offered in the following areas: ancient art, medieval and Byzantine art, Renaissance and baroque art, and modern art. Special research opportunities are available through the Center for the Study of Renaissance and Baroque Art.

Candidates for the M.A. degree are required to complete a master's thesis and to demonstrate a reading knowledge of two foreign languages, one of which must be German. The other language is normally French or Italian. Reading knowledge of one of these languages must be demonstrated before the end of four terms of study. These regulations apply equally to Ph.D. students. For those students wishing to enter the doctoral program who have already completed a master's degree from another university, a reading knowledge of one foreign language will be required before the student can be considered for admission to the department.

Candidates with a 3.00 junior-senior grade-point average and a minimum of 21 credits in art history will be considered for admission to the master's program. Lacking these, a promising candidate may be accepted on condition that deficiencies be remedied, but without graduate degree credit. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

ART HISTORY (ART H)

- 400. **STUDIES IN ART HISTORY (3-6 per term)**
- 401. **STUDIES IN GREEK ART (3)**
- 402. **THE ILLUMINATED MANUSCRIPT (3)**
- 404. **THE ART OF COLONIAL AMERICA (3)**
- 405. **PIONEERS OF MODERN ARCHITECTURE (3-6)**
- 410. **TASTE AND CRITICISM IN ART (3)**
- 411. **ART OF IMPERIAL ROME (3)**
- 412. **THE GOTHIC CATHEDRAL (3)**
- 414. **STUDIES IN ITALIAN BAROQUE ART (3-9)**
- 415. **THE SKYSCRAPER (3)**
- 416. **AMERICAN PAINTING: 1876-1913 (3)**
- 422. **STUDIES IN MEDIEVAL SCULPTURE (3)**
- 423. **STUDIES IN ITALIAN RENAISSANCE ART (3-9)**
- 424. **MASTERS OF NORTHERN BAROQUE ART (3)**
- 425. **MOVEMENTS IN NINETEENTH-CENTURY ART (3)**
- 430. **GOYA AND HIS TIMES (3)**
- 432. **PROBLEMS IN ICONOLOGY (3)**
- 435. **MOVEMENTS IN TWENTIETH-CENTURY ART (3-6)**
- 450. **THE HISTORY OF PHOTOGRAPHY (3)**
- 451. **SURVEY OF SPANISH BAROQUE PAINTING (3)**
- 452. **PAINTING IN THE AGE OF LOUIS XIV (3)**
- 456. **GIAN LORENZO BERNINI AND THE ARCHITECTURE OF THE FULL BAROQUE IN ROME (3)**

ASTRONOMY

458. ROMAN ROCOCO ARCHITECTURE AND THE DAWN OF NEOCLASSICISM (3)

497. SPECIAL TOPICS (1-6)

510. STUDIES IN ART HISTORY (3-6 per term) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.

511. SEMINAR IN ANCIENT ART (3-12) Selected topics from the history of Greek and Roman art.

512. SEMINAR IN MEDIEVAL ART (3-12) Original research into problems dealing with the art of the Middle Ages.

513. SEMINAR IN RENAISSANCE ART (3-12) Investigations in the area of Renaissance art, centering around major masters and monuments.

514. SEMINAR IN BAROQUE ART (3-12) Investigations in the area of baroque art, centering around major masters and monuments.

515. SEMINAR IN MODERN ART (3-12) Lectures, readings, reports, and discussions in the field of modern art.

517. SEMINAR IN EIGHTEENTH-CENTURY ART (3-12) Investigation into themes and problems dealing with eighteenth-century art.

520. SEMINAR IN SPANISH BAROQUE PAINTING (1-6) Specific problems in the history of seventeenth-century Spanish painting.

522. SEMINAR IN BYZANTINE ART (3-12) Specific iconographical and stylistic problems in Byzantine art and its relation to classical antiquity, the medieval West, and Islam.

525. SEMINAR IN MODERN ARCHITECTURE (3-12) Investigation into the works and problems of modern architecture as they relate to the culture of our times.

542. THE ILLUSTRATION OF THE APOCALYPSE (3-6) Studies in the illustration of the Apocalypse, iconographical and stylistic, from the early Christian period through Dürer.

551. HISTORIOGRAPHY OF ART HISTORY (1-6) The relationship between the definition of, and approach to, art-historical problems from Vasari to the present.

552. PROBLEMS IN CONNOISSEURSHIP (3) A study of the problems of authenticating, attributing, and dating paintings and sculpture through internal evidence.

555. ART HISTORY FIELD SEMINAR (3-12) Investigations based on the site study of specific art objects, with trips in successive years to different art centers.

ASTRONOMY (ASTRO)

SATOSHI MATSUSHIMA, *Head of the Department*
525 Davey Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Matsushima, Sampson, and Usher.

Graduate Faculty: Associate Members Bauer, Panek, Ramsey, Winkler, and Zabriskie.

Graduate instruction and research opportunities are available in both observational and theoretical astronomy and astrophysics. The areas of current research interest include: atomic processes and radiative transfer, theory of stellar and planetary atmospheres, stellar structure and pulsation theory, gaseous nebulae and interstellar matter, quasi-stellar objects and variable galaxies, solar physics, objects in the solar system, eclipsing binaries and binary star systems, cosmology, astrophysical photometry and spectroscopy, and astronomical instrumentation. Opportunities for thesis research also are offered, in cooperation with other departments, in plasma and high-energy astrophysics, nucleosynthesis, and relativity.

Research facilities include a new observatory near the Black Moshannon State Park, located 25 miles north of the University Park Campus, which is equipped with telescopes of 152 cm and 61 cm aperture with instrumentation for spectroscopic and photometric observations.

Modern astronomy has very close ties with mathematics, physics, and engineering. The program required of a doctoral candidate would normally include courses in at least two of these related fields, in addition to those in astronomy. Two of three foreign languages chosen from French, German, or Russian are required. A knowledge of computer programming may be substituted for one of the two foreign languages required. The nonthesis option is available for the M.S. degree.

Applicants with a bachelor's degree in astronomy or an allied field such as physics, mathematics, or geophysics are given equal consideration for admission. Opportunity to make up possible undergraduate deficiencies is provided. A grade-point average of 3.00 or better for junior-senior courses in astronomy and related subjects is necessary for consideration for admission, although exceptions to this minimum requirement may be made for students with special backgrounds, abilities, and interests.

ASTRONOMY (ASTRO)

- 430. GENERAL ASTRONOMY FOR TEACHERS (3)
- 460. FUNDAMENTALS OF CELESTIAL MECHANICS (3)
- 470. SOLAR PHYSICS (3)
- 490. INTRODUCTION TO ASTROPHYSICS (3)
- 492. (E.E. 492) SPACE ASTRONOMY AND INTRODUCTION TO SPACE SCIENCE (3)
- 495. PRACTICAL ASTRONOMY (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 510. ASTROPHYSICS (3) An introduction to astrophysics in which the relevant physics, spectra, gas laws, plasmas, and radiation transfer theory are discussed.
- 511. ASTROPHYSICS (3) Stellar atmospheres; considerable emphasis is placed on the sun and on solar-terrestrial relationships. Prerequisite: Astro. 510.
- 513. OBSERVATIONAL TECHNIQUES IN ASTRONOMY (3) Radiation quantities in theory and as observed. Astrometry, photometry, spectroscopy, stellar classification, interferometric methods. Observational laboratory. Prerequisite: Astro. 511.
- 514. OBSERVATIONAL PRACTICE (1-3) Practice of the use of research instruments, data acquisition, and reduction at the optical or radio observatory sites. Prerequisite: Astro. 511 or 513.
- 524. CELESTIAL MECHANICS AND SPHERICAL ASTRONOMY (3) Two-body and one-body theory, elliptic motion, expansions, two-body orbit in space, coordinate transformations, planetary equations. Lagrange and Hamilton mechanics. Prerequisites: Math. 452, Phys. 419.
- 530. THEORY OF STELLAR ATMOSPHERES (3) Theory of photospheric structure, radiative processes, and line-formation in the outer layers of stars, and interpretation of stellar spectra. Prerequisite: Astro. 511.
- 531. THEORY AND ANALYSIS OF SPECTRAL LINES (3) The formation of spectral lines for both the LTE and NLTE cases, analysis of both line profiles and integrated intensities. Prerequisite: Astro. 530.
- 534. STELLAR STRUCTURE AND EVOLUTION (3) Theory of physical processes, structure, and evolutionary changes of stars; nature of intrinsic variable stars; the Hertzsprung-Russell diagram. Prerequisite: Astro. 510 or Phys. 561.
- 542. GASEOUS NEBULAE AND INTERSTELLAR MATTER (3) Theory and observations of galactic nebulae and interstellar medium, and problems related to the formation of stars and galactic structure. Prerequisite: Astro. 511.
- 582. RADIO ASTRONOMY (3) Radiometers and antennas; signals in noise; solar physics; quiet and active solar radiation; transfer equation and solar radiation; solar-terrestrial effects. Prerequisite: E.E. 438 or Phys. 467.

583. GALAXIES, QUASARS, AND COSMOLOGY (3) Structure and population of the Milky Way galaxy, properties of galaxies, properties and nature of Quasars, distance scale and deacceleration parameter. Prerequisite: Astro. 582.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

BIOCHEMISTRY (BIOCH)

M. FRANK MALLETTE, *In Charge of Graduate Programs in Biochemistry*
206 Althouse Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aronson, Fahnestock, Hammerstedt, Hartzell, W. Karakawa, Mallette, McCarl, Pazur, Phillips, R. Schraer, Shigley, and Warne.

Graduate Faculty: Associate Member J. Karakawa.

Opportunities for research and graduate study are available in intermediary metabolism, cellular control mechanisms, molecular genetics, enzyme structure, nucleic acids, proteins, carbohydrates, lipids, endocrinology, subcellular structures, computer applications, biochemistry of reproduction, heart cell culture, and immunochemistry.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of one foreign language which is widely used by biochemists.

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are not required for admission.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOCHEMISTRY (BIOCH)

401. GENERAL BIOCHEMISTRY (3)

402. GENERAL BIOCHEMISTRY (3)

403. EXPERIMENTAL BIOCHEMISTRY (3)

417. BIOCHEMICAL METHODS (4)

425. INTRODUCTORY PHYSICAL BIOCHEMISTRY (4)

437. PHYSIOLOGICAL BIOCHEMISTRY (3)

438. PHYSIOLOGICAL METHODS (2)

451. SENIOR SEMINAR (1)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

503. BIOCHEMICAL PROBLEMS (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor.

507. SEMINAR IN BIOCHEMISTRY (1 per term)

514. MOLECULAR BIOLOGY AND CELLULAR REGULATION (3) Structure, synthesis, and biochemical properties of nucleic acids; protein biosynthesis; control of gene expression; molecular genetics. Prerequisite: Bioch. 402.

520. CARBOHYDRATES, LIPIDS, AND THEIR INTEGRATED METABOLISM (3) Chemistry of carbohydrates, lipids, and membranes; interrelationships between lipid and carbohydrate biosynthesis and metabolism. Prerequisite: Bioch. 402.
525. PROTEINS AND ENZYMES (3) Properties of proteins and polypeptides, structural analysis and molecular interactions; enzyme structure, kinetic mechanisms, and control. Prerequisite: Bioch. 402.
590. COLLOQUIUM (1-3)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

BIOENGINEERING (BIOE)

D. B. GESELOWITZ, *Chairman of the Program Committee in Bioengineering*
328 Hammond Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Adams, Anthony, Brickman, Buskirk, Davids, Fonash, Geselowitz, Hollis, Jacobs, Kenney, Kline, Michael, Morrow, Munger, Park, Phillips, Pierce, Sharma, Ultman, Weidner, and Zelis.

Graduate Faculty: Associate Members Arnett, Liedtke, and Nellis.

This intercollege program is designed to provide the student with graduate-level training in engineering and in the life sciences, and specialized training in specific areas of interaction of engineering with biology and medicine. Graduate instruction in bioengineering is under the direction of a program committee composed of Graduate Faculty representing several departments.

Opportunities for specialized research include electrical and mechanical properties of biological materials, development of an artificial heart, hemodynamics, electrocardiography, applications to nuclear medicine and radiology, biomaterials, lung mechanics, bioinstrumentation, transducers, and neurophysiology of vision.

The particular course of study depends on the student's background and area of research specialization. Courses are selected from the life sciences, engineering, and bioengineering. Candidates for the Ph.D. degree generally are expected to complete Phsio. (Biol.) 571-573 plus several additional courses in the life sciences, five courses in bioengineering, and five graduate-level courses in engineering, mathematics, and physics. Supporting courses are available at University Park and The Milton S. Hershey Medical Center in acoustics, anatomy, biochemistry, biology, biophysics, chemistry, laboratory animal medicine, materials science, mathematics, physiology, polymer science, psychology, and the engineering departments.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by demonstrating intermediate knowledge of an acceptable foreign language, or by taking an advanced technical writing course and presenting a formal proposal for thesis research to the doctoral committee.

A thesis is required for the M.S. degree. Course requirements include Bioe. 401 and 402 plus two 500-level courses in bioengineering, 6 credits in the life sciences including Biol. 472, and 6 credits in technically oriented courses outside of bioengineering and the life sciences. In addition, students without a previous degree in engineering or physics would be expected to complete the equivalent of the following courses during the first year: E.E. 103 and 340, E.Mch. 111 and 112, Aersp. 308.

Students with a degree in engineering, physics, or the life sciences will be eligible for admission. All students must have a strong background in physics and mathematics. This background should include 9 credits in chemistry, 9 credits in physics, mathematics through calculus and differential equations, and a course in linear systems analysis. Students who lack one or two courses may still be considered for admission but will have to make up any deficiency early in their graduate program. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOENGINEERING (BIOE)

- 401. INTRODUCTION TO BIOENGINEERING (3)
- 402. BIOMEDICAL INSTRUMENTATION AND MEASUREMENTS (3)
- 425. (Nuc.E. 425) RADIOGRAPHIC IMAGING (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. BIOENGINEERING TRANSPORT PHENOMENA (3) Application of the equations of mass, energy, and momentum conservation to physiological phenomena and to the design of artificial organs.
- 502. INTRODUCTION TO BIOELECTRIC PHENOMENA (3) Electric phenomena in nerve and muscle, membrane potentials, Hodgkin-Huxley equations, volume conductor problem, applications to electrocardiography, electroencephalography, plethysmography.
- 503. FLUID MECHANICS OF BIOENGINEERING SYSTEMS (3) Cardiovascular system and blood flow, non-newtonian fluid description, vessel flows, unsteady flows and wave motion, windkessel theory, transmission line theory.
- 504. PHYSIOLOGICAL SYSTEMS ANALYSIS (3) Application of systems theory, control theory, and analytic modeling strategies to the study of physiological systems. Prerequisites: Biol. 472, Engr. 100.
- 505. BIOENGINEERING MECHANICS (3) Passive and active mechanical properties of tissues, rheological materials, models of muscle contraction, pulmonary mechanics, forces in muscular-skeletal system.
- 580. BIOENGINEERING INTERNSHIP (3-6) Supervised experience at The Milton S. Hershey Medical Center including rotation through services and work on a minor project. Prerequisites: Bioe. 402 and 3 credits in bioengineering at the 500 level.
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

BIOLOGICAL CHEMISTRY (BCHEM)

EUGENE A. DAVIDSON, *Chairman of the Department*
The Milton S. Hershey Medical Center
Hershey, PA 17033

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Davidson, Hass, Hill, McPherson, Miljkovic, Rosenberg, Shiman, and Taylor.

Graduate Faculty: Associate Members Bhayanandan and Schengrund.

Opportunities for research and graduate study are available in the chemistry and metabolism of complex polysaccharides, cellular differentiation, mechanism of enzymatic reactions, biochemical genetics, biochemistry of complex lipids, conformational analysis of carbohydrates and proteins, natural product chemistry, and physical chemistry of macromolecules.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. The nonthesis option is available for the M.S. degree.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Interested students should contact the department chairman.

The program is offered only at The Milton S. Hershey Medical Center.

BIOLOGICAL CHEMISTRY (BCHEM)

502. **BIOLOGICAL CHEMISTRY I (3)** Structure-function relationships of macromolecules; pathways utilized for energy generation in mammalian systems; concepts of metabolic regulation.
503. **NUCLEIC ACID BIOCHEMISTRY (2)** Aspects of the mechanism and control of nucleic acid and protein biosynthesis with emphasis on their relationship to genetic phenomena. Prerequisite: Micrb. 556.
504. **BIOLOGICAL CHEMISTRY LABORATORY (2)** Laboratory exercises in biological chemistry related primarily to mammalian systems. Experience with a range of contemporary techniques. Prerequisite or concurrent: B.Chem. 502.
505. **BIOLOGICAL CHEMISTRY II (3)** A continuation of B.Chem. 502. Emphasis on interrelations of metabolic pathways, catabolic end products, and regulation. Prerequisite: B.Chem. 502.
513. **BIOLOGICAL CHEMISTRY, MACROMOLECULES (3)** Physical chemistry of macromolecules; techniques for investigating conformations, size, and interactions. Development and application of thermodynamics to solutions of macromolecules.
523. **METABOLISM (3)** Molecular mechanisms employed by living systems to transform biological compounds, control production and utilization of energy, and regulate metabolic pathways.
551. **KINETICS AND MECHANISM OF ENZYME ACTION (3)** Current kinetic theory, rapid reactions, regulatory enzymes, chemical and physical approaches to the study of the mechanism of enzyme action. Prerequisite: B.Chem. 502. Concurrent: B.Chem. 523.
553. **BIOCHEMICAL TECHNIQUES (3)** Lectures and discussion on approaches to macromolecule and lipid separation and characterization; isolation of subcellular organelles; enzymatic assay; radioisotopes. Prerequisite: B.Chem. 502.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

BIOLOGICAL SCIENCE (BI SC)

E. S. LINDSTROM, *In Charge of Graduate Programs in Biological Science*
208 Erwin W. Mueller Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cooper, Fergus, Grove, Grun, Hamilton, Hillson, Hollis, Keener, MacCluer, Pursell, Schein, Spackman, Therrien, Traverse, Wickersham, Williams, Witham, and Wright.

Graduate Faculty: Associate Members Mitchell and Neff.

The M.Ed. program in biological science is designed primarily to meet the needs of secondary school science teachers. The academic degrees M.S. and Ph.D. are not offered in biological science but are available in biochemistry, biology, biophysics, botany, entomology, genetics, microbiology, physiology, plant pathology, and zoology.

The candidate for the M.Ed. degree must earn at least 21 credits in the natural sciences with a minimum of 15 credits in the biological sciences, including at least 6 in the animal sciences and 6 in the plant sciences. In addition, at least 6 credits in education and a term paper are required. It is suggested that the candidate have at least two years of teaching experience before applying to this program.

The D.Ed. program is designed for secondary school and college science teachers. Major course requirements are designated by the candidate's committee with the concept that teachers of biology have a broad background in biological disciplines and related fields. A minimum of 15 credits each is required in professional education and in thesis research. The requirement of a foreign language is at the discretion of the candidate's committee.

In order to enter a program for a higher degree with a major in biological science, the candidate should present 30 credits in the natural sciences, including one year of organic chemistry and one year of physics. A limited number of undergraduate deficiencies may be made up in pursuit of the advanced degree. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOLOGY (BIOL)

E. S. LINDSTROM, *Head of the Department*
208 Erwin W. Mueller Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cooper, Dunson, Fergus, Graves, Grove, Grun, Hamilton, Hibbard, Hillson, Hollis, Keener, MacCluer, Pursell, Schein, Spackman, Therrien, Traverse, Wickersham, Williams, Witham, and Wright.

Graduate Faculty: Associate Members Arnold, Beatty, Burris, Dachtler, Mitchell, Neff, Pearson, Reimer, Rheuben, and Turpen.

The department will direct graduate programs in behavior, cell biology, cytology, cytochemistry, environmental science, ultrastructure, and other aspects of modern biology. The courses of study are planned individually by the student and an adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. Candidates have the option of a thesis or a paper for the M.S. degree.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide scores from the Graduate Record Examination, a personal statement of interests and objectives, and letters from two persons verifying the applicant's academic competence.

BIOLOGY (BIOL)

- 402. VERTEBRATE NEUROANATOMY (3)
- 404. PRACTICUM IN EXPERIMENTAL NEUROANATOMY (1-4)
- 407. PLANT ANATOMY (3)
- 409. BIOLOGY OF AGING (3)
- 410. GENERAL LIMNOLOGY (3)
- 412. PLANT BIOLOGY FOR TEACHERS (3)
- 414. ADVANCED SYSTEMATIC BOTANY (3)
- 417. INVERTEBRATE ZOOLOGY (4)
- 418. MYCOLOGY (3)
- 419. GENERAL ECOLOGY (3)
- 420. (G.Sc. 420) PALEOBOTANY (3)
- 421. COMPARATIVE ANATOMY OF VERTEBRATES (4)
- 422. ADVANCED GENETICS (3)
- 423. (G.Sc. 423) INTRODUCTORY PALYNOLOGY (3)
- 426. INTRODUCTORY CYTOGENETICS (3)
- 427. (G.Sc. 427) EVOLUTION (3)
- 428. POPULATION GENETICS (3)
- 429. DEVELOPMENTAL GENETICS (3)
- 431. COMPARATIVE PLANT MORPHOLOGY (2)
- 432. LABORATORY IN COMPARATIVE PLANT MORPHOLOGY (2)
- 433. TERRESTRIAL ECOLOGY (3)
- 434. TERRESTRIAL ECOLOGY LABORATORY (2)
- 435. ECOLOGY OF LAKES AND STREAMS (3)
- 436. FRESHWATER ECOLOGY RESEARCH TECHNIQUES (3)
- 437. HISTOLOGY (4)

438. ORNITHOLOGY (2)
 439. ORNITHOLOGY LABORATORY (1)
 440. EMBRYOLOGY (4)
 441. PLANT PHYSIOLOGY (3)
 442. PLANT PHYSIOLOGY (3)
 445. PHYTOHORMONES (3)
 451. PLANT SYNECOLOGY (3)
 452. ICHTHYOLOGY (3)
 454. HERPETOLOGY (2)
 462. (Pty.Sc. 462) ANIMAL BEHAVIOR — ETHOLOGY (3)
 463. (Pty.Sc. 463, Psy. 463) ANIMAL BEHAVIOR LABORATORY (1-2)
 465. GENERAL CYTOLOGY (3)
 466. LABORATORY IN CYTOLOGY (1)
 472. VERTEBRATE PHYSIOLOGY (3)
 473. LABORATORY IN VERTEBRATE PHYSIOLOGY (2)
 476. PHYSIOLOGY OF PULMONARY RESPIRATION (2)
 477. BIOLOGY OF HUMAN SEXUALITY (3)
 478. BIOLOGICAL AND MEDICAL ASPECTS OF THE MAMMARY GLAND (2)
 479. GENERAL ENDOCRINOLOGY (3)
 480. MARINE BIOLOGY (4)
 481. AQUATIC BOTANY (3)
 482. COASTAL BIOLOGY (4)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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502. THE PHYSIOLOGY OF THE FUNGI (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years.
 504. Bphys. 504) SEMINAR IN CELL BIOLOGY (1) Discussion of current problems and ideas in cell biology with emphasis on reference to recent literature.
 506. COMPARATIVE ANATOMY OF VASCULAR PLANTS (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Biol. 407. Spring term, even years.
 511. ADVANCED PLANT PHYSIOLOGY (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration and catabolism. Prerequisite: Biol. 442. Fall term.
 512. ADVANCED PLANT PHYSIOLOGY (3) Continuation of Biol. 511. Physiology of plants including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: Biol. 442. Winter term.
 516. ECOLOGICAL PLANT GEOGRAPHY (3) Distribution of plant communities; environmental factors which influence their present distribution; geological-historical development of plant communities, their past distribution. Winter term, odd years.
 517. FISH BEHAVIOR AS RELATED TO AQUATIC ECOLOGY (3) Receptor-effector systems, selection of habitat and the effects of behavioral interaction on population levels, growth and survival. Prerequisite: Biol. 452 or 462.
 518. SPECIAL PROBLEMS (1-6) Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.
 519. ZOOGEOGRAPHY (3) The present distribution of world vertebrates, their evolution, and their patterns of dispersal in the past.
 522. LOWER FUNGI (3) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Biol. 418. Winter term, even years.
 523. HIGHER FUNGI (3) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Biol. 418. Spring term, even years.
 524. SEMINAR IN GENETICS (1 per term)

526. (Geol. 526) **PROBLEMS IN PALYNOLOGY** (1-6) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history.
531. **BRYOLOGY** (3) Morphology, taxonomy, and ecology of liverworts, hornworts, and mosses; collection, preservation, culturing, and cytologic techniques. Spring term, even years.
533. **PROBLEMS IN GENETICS** (2-6) Problems to suit needs of individual students; conferences and laboratory work.
535. **MORPHOLOGY OF THE TRACHEOPHYTA EXCLUSIVE OF ANGIOSPERMS** (3) Origin, developmental tendencies, structure, and paleobotanical evidence. Winter term, odd years.
536. **MORPHOLOGY OF ANGIOSPERMS** (3) Floral origin and development, fertilization, embryogeny, seeds and fruit development. Prerequisite: Biol. 431.
538. **PRINCIPLES OF MICROSCOPIC HISTOCHEMISTRY** (2) Theoretical basis for the microscopic identification, localization, and quantitative analysis of chemical substances in tissues of organisms. Prerequisite: Biol. 405 or 437.
539. **ANALYTICAL HISTOCHEMISTRY LABORATORY** (2-4) Application of histochemical techniques in the microscopic analysis of tissue lipids, proteins, carbohydrates, nucleic acids and proteins. Prerequisite or concurrent: Biol. 538.
540. **PHYCOLOGY** (4) Comparative morphology, taxonomy, and ecology of freshwater and marine algae; culturing, collection, preservation techniques.
542. (Ent. 542) **SYSTEMATICS** (3) Principles and methods of classification, phylogeny and speciation; taxonomic techniques, analysis of species; causal interpretation of animal diversity.
544. **PHYSIOLOGICAL ECOLOGY** (3) The physiological abilities of animals to tolerate and compensate for changes in the physical and chemical nature of the environment.
545. **ECOSYSTEM DYNAMICS** (3) Analysis of the ecosystem concept based on consideration of ecosystem energetics, components, biotic and abiotic, function, and temporal relations. Prerequisite: Biol. 210.
546. **ECOLOGY OF POPULATION AND COMMUNITIES** (3) Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term.
547. **INVERTEBRATE BIOLOGY** (3) Embryological development, metamorphosis, regeneration, and endocrinology of selected invertebrate groups (insects excluded). Invertebrate interactions and ecological impact.
550. **NEUROGENESIS** (2) Embryonic and evolutionary development of the nervous system. Determination, differentiation, orientation, and specificity of growing and regenerating nerve cells. Prerequisite: Biol. 440.
557. (Sci.Ed. 557) **WORKSHOPS IN THE BIOLOGICAL SCIENCES** (3) Projects designed for teachers of biology in the secondary schools. Summer term only.
571. (Phsio. 571) **ANIMAL PHYSIOLOGY** (2) Mammalian cardiovascular system; mammalian neurophysiology; excitable tissue, sensory systems, motor systems, and autonomic system. Prerequisite: Biol. 472.
572. (Phsio. 572) **ANIMAL PHYSIOLOGY** (2) Mechanisms involved in the activity and control of gastrointestinal function, respiration, and renal regulation of blood and body fluids. Prerequisite: Biol. 472.
573. (Phsio. 573) **ANIMAL PHYSIOLOGY** (2) Hypothalamic-hypophyseal relationships. Reproductive cycle regulation, endocrine control of fluid balance, body temperature, energy homeostasis, and metabolism of protein and minerals. Prerequisite: Biol. 472.
582. (Pty.Sc. 582, Psy. 582) **RESEARCH IN ANIMAL BEHAVIOR** (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.
585. (Bphys. 585) **BIOLOGICAL ULTRASTRUCTURE** (4) The application of electron microscopy to the study of cell biology. Prerequisite: Bphys. 473 or Biol. 437 or 465 or Micrb. 401.

BIOPHYSICS (BPHYS)

REGINALD A. DEERING, *In Charge of Graduate Programs in Biophysics*
618 Erwin W. Mueller Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Deering, Ginoza, Hymer, Keith, Morgan, Person, H. Schraer, Smyth, Snipes, Strother, Taylor, and Todd.

The major goal of this program is to train students for independent research and teaching in the interdisciplinary areas of biophysics and molecular biology. The students currently in the department have come from a variety of fields including physics, engineering, chemistry, biochemistry, and biology. Graduate students are expected to begin a research program during their first year of study. Personal attention is given by a faculty adviser to insure that the program is suited to the student's talents and is one that will permit the earning of a degree in a reasonable time. Course requirements are flexible and depend to a considerable extent on the student's research interests. The master's program is expected to take from six to eight terms (four terms per year), and the Ph.D. usually requires an additional eight to twelve terms, including thesis research. Advancement to Ph.D. candidacy is decided on the basis of course and research performance in addition to a written examination. A comprehensive oral examination and thesis defense are integral parts of the Ph.D. program. Knowledge of a foreign language may be required depending on the area of research.

Research interests include radiation biology and DNA repair, cell biology, molecular biology and genetics, electrophysiology, structure and function of biological membranes, molecular virology, developmental biology, biophysical chemistry, pituitary cell physiology, cytofluorometry, electron microscopy, and chemical carcinogenesis.

BIOPHYSICS (BPHYS)

- 415. STRUCTURE OF BIOLOGICAL MACROMOLECULES (2)
 - 430. MOLECULAR BIOLOGY OF THE GENE (3)
 - 440. STRUCTURE AND FUNCTION OF BIOLOGICAL MEMBRANES (3)
 - 473. MOLECULAR BIOPHYSICS I (3)
 - 474. MOLECULAR BIOPHYSICS II (3)
 - 475. INTRODUCTORY RADIATION BIOPHYSICS (3)
 - 476. NEUROPHYSIOLOGY (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
503. BIOPHYSICS OF MEMORY (2) Molecular biology, pharmacology and physiology of learning, memory formation and recall. Reading and discussion of the pertinent current literature. Prerequisite: Bioch. 401 or Bphys. 475.
504. (Biol. 504) SEMINAR IN CELL BIOLOGY (1) Discussion of current problems and ideas in cell biology with emphasis on reference to recent literature.
577. MOLECULAR EVOLUTION AND DIFFERENTIATION (3) Evolution and differentiation studied by methods of denaturation and reassociation of DNA, RNA, and amino acid sequences. Current laboratory practice. Prerequisite: Bioch. 41 or 401 or Bphys. 473.
579. PHOTOBIOLOGY (2) Effects of visible and ultraviolet light on biological systems: energy absorption, transfer, utilization; photochemistry; metabolic and genetic responses; repair systems.
585. (Biol. 585) BIOLOGICAL ULTRASTRUCTURE (4) The application of electron microscopy to the study of cell biology. Prerequisite: Bphys. 473 or Biol. 437 or 465 or Microb. 401.
587. ULTRACENTRIFUGATION (2) A laboratory course in ultracentrifugation techniques including applications to biophysical problems. Prerequisite: Bphys. 474.

588. **PHYSIOLOGY OF NERVES, MUSCLES, AND SENSE ORGANS (2-6)** Current literature of the function of nerves, muscles, and receptors. These subjects are considered individually in successive years. Prerequisite: a 400-level course in physiology, biophysics, or physiological psychology.

589. **MAMMALIAN CELL CULTURE (3)** Recent research in quantitative cell biology as studied with tissues and cells of higher organisms cultured *in vitro*. Prerequisite: Bioch. 401.

590. **COLLOQUIUM (1-3)**

595. **ELECTRON SPIN RESONANCE SPECTROSCOPY (3)** Experimental and theoretical aspects of electron spin resonance spectroscopy to provide ability for its application to biophysical problems. Prerequisite: basic knowledge of quantum mechanics and electromagnetic waves.

597. **SPECIAL TOPICS (1-6)**

BOTANY (BOT)

E. S. LINDSTROM, *Head of the Department of Biology*
208 Erwin W. Mueller Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Fergus, Grove, Grun, Hamilton, Hillson, Keener, Pursell, Schein, Spackman, Therrien, Traverse, Witham, and Wright.

Graduate Faculty: Associate Member Burris.

Botanical programs are offered in plant anatomy, bryology, cytology, ecology, genetics, morphology, mycology, paleobotany, palynology, physiology, and taxonomy. A student having a degree in science or in one of the biological sciences is eligible for admission. Entering graduate students should have had basic courses in chemistry, mathematics, and physics. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide scores from the Graduate Record Examination, a personal statement of interests and objectives, and letters from two persons verifying the applicant's academic competence.

See also Genetics and Physiology.

NOTE: *For courses in Botany and related subjects see Biology.*

BUSINESS ADMINISTRATION (B A)

STEWART W. BITHER, *Director of the M.B.A. Program*
JOHN D. DANIELS, *Director of the M.S. and Ph.D. Programs*
101 Business Administration Building

Degrees Conferred: Ph.D., M.S., M.B.A.

Graduate Faculty: Senior Members Aggarwal, Bear, Beik, Bennett, Bither, Bradley, Carroll, Coyle, Cramer, Curley, Daniels, Dinkel, Ezzell, Ferrara, Fishburn, Greenlaw, Hammond, Hayya, Heitmann, Hottenstein, Kelley, Kleindorfer, Kochenberger, Koot, Malcom, Olson, Pashek, Philippatos, Philips, Radebaugh, Richards, Rigby, Schrader, Sheridan, Shilling, Sims, Slocum, Spychalski, Susman, and D. Wilson.

Graduate Faculty: Associate Members Basi, Bluedorn, Dirsmith, Durkin, Eyerly, Gouldey, Henszey, Holman, Jablonsky, Koehler, Lantz, Lusht, Marlow, Melander, Millman, Myers, Nelson, Phalan, Pitts, Raju, Reutzel, Shapiro, Snow, Stenger, Thies, Tretter, Twark, Tyworth, VanLandingham, Watson, Williams, and R. Wilson.

The Master of Business Administration is a professional degree program in business administration designed to prepare individuals for managerial positions in business, as well as government and other nonprofit institutions. Individuals of all undergraduate disciplines, both business and nonbusiness, are encouraged to apply. This program consists of two distinct portions: (1) 3 credits each in undergraduate accounting, statistics, and economics (not exclusively macroeconomics). These prerequisite courses may be taken as part of an undergraduate curriculum or at the University prior to starting graduate-level studies; (2) 45 credits of graduate courses and a professional paper.

Graduate-level work on the M.B.A. degree may be started fall term only. The time required to complete the graduate program, based on full-time study, is fifteen months. The student body is divided into diverse sections of approximately forty students, with each section proceeding through the same core classes. Emphasis is placed on student interaction and shared learning both inside and outside the classroom.

The M.S. and Ph.D. programs with a major in business administration are designed for those interested primarily in research and teaching. The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of two foreign languages or a reading, listening, and speaking knowledge of one language. The candidate may substitute quantitative analysis and/or behavioral science for the required reading knowledge in one or two languages. A student has an option of a thesis or a paper for the M.S. degree.

For admission to the M.S. program, approximately 33 acceptable undergraduate credits in business administration, economics, and mathematics are required. An applicant may be admitted without foundation courses, but they must be made up without degree credit. Applicants are evaluated for admission on the basis of academic potential and other factors giving evidence of high probability of completing the program. Data useful for evaluating academic potential include the applicant's professional and academic accomplishments, the Graduate Management Admission Test (GMAT) scores, and recommendations. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Applicants to any of the graduate programs in business administration are required to take the Graduate Management Admission Test (GMAT) which is administered by the Educational Testing Service four times a year. For dates, locations, and any other information on the test, write for the *Bulletin of Information*, Graduate Management Admission Test, Educational Testing Service, Princeton, New Jersey 08540.

This graduate program is accredited by the American Association of Collegiate Schools of Business.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

ACCOUNTING (ACCTG)

- 401. ADVANCED ACCOUNTING (3)
- 403. AUDITING (3)
- 404. MANAGERIAL ACCOUNTING (3)
- 406. ADVANCED FEDERAL TAXATION (3)
- 409. ACCOUNTING INFORMATION SYSTEMS (3)
- 421. INTERNATIONAL ACCOUNTING (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

*398G. ACCELERATED ELEMENTARY ACCOUNTING (3) The theory and technique of financial and managerial accounting: preparation, analysis, and interpretation of financial statements. Open to graduate students only.

501. RESEARCH METHODS IN ACCOUNTING (3) An introduction to the methods and techniques of contemporary research in accounting. Prerequisites: Acctg. 504, 507, and a course in statistical inference.

*No graduate credit is given for this course.

503. SEMINAR IN AUDITING (3) The attest function of independent public accountants, verification of financial statements; problems of evidence, independence, ethics, professional responsibilities. Prerequisite: Acctg. 403.
504. SEMINAR IN MANAGERIAL ACCOUNTING (3-6) Accounting and the managerial processes of planning, control, and decision making.
507. SEMINAR IN FINANCIAL ACCOUNTING (3) Theoretical basis of financial accounting.
508. CONTEMPORARY ISSUES IN ACCOUNTING (3) Selected problems of current interest to the accounting profession.
511. FINANCIAL AND MANAGERIAL ACCOUNTING (3) Fundamental financial and managerial accounting concepts and issues from the viewpoint of the report user.
512. FINANCIAL ACCOUNTING THEORY AND REPORTING PROBLEMS (3) Measurement and reporting of financial information for external purposes, with particular attention to current problems in asset and income measurement. Prerequisite: Acctg. 511.
514. SEMINAR IN FEDERAL TAXATION (3) The federal tax structure, including legal, economic, and government implications; focusing on business decisions, research methodology, and tax planning.
515. DEVELOPMENT OF ACCOUNTING THOUGHT (3) Development of accounting thought from ancient civilizations to the present.
516. SEMINAR IN NOT-FOR-PROFIT ACCOUNTING (3) Measurement and structuring of financial information for managerial planning and control and external reporting.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2)

BUSINESS ADMINISTRATION (B A)

496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
499. FOREIGN STUDY IN BUSINESS ADMINISTRATION (2-6)
503. SEMINAR IN PUBLIC UTILITIES (3)
537. (Cmp.Sc. 537) MANAGEMENT INFORMATION SYSTEMS DESIGN (3) Cost, value, and technical considerations in analysis and design of information systems whose purposes are to aid decision making in organizations.
538. INFORMATION SYSTEMS FOR PLANNING AND CONTROL (3) Analysis of information requirements for planning, decision making, and performance measurement in organizations.
539. SEMINAR IN MANAGEMENT INFORMATION SYSTEMS (3) Special topics selected from contemporary issues in management information systems.
550. BEHAVIORAL SCIENCE IN BUSINESS (3) Application of behavioral science concepts and analytical methods to problems in business organizations. Analysis of administrative behavior and decision making.
555. BUSINESS AND SOCIETY (3) Evolution of the business organization and the changing framework of its operations, responsibilities, and social control.
560. ENTERPRISE CONSULTING (3) Student groups engaging in consulting relationships with enterprises through use of managerial techniques for identification, analysis, and solution of managerial problems. Prerequisites: Acctg. 511; B.A. 550, 555; Econ. 500; Q.B.A. 510 and 521.
574. BUSINESS RESEARCH (1-3) A project paper, comparable in quality and scope of work to a

graduate thesis, on problems of a company. Prerequisite: 15 credits of 400- and 500-level courses in business administration.

577. ADMINISTRATIVE INTEGRATION (3) An analysis of coordination of the functional areas of business in relation to overall company objectives. Prerequisite: 15 credits of 400- and 500-level courses in business administration.

578. ENTREPRENEURSHIP (3) Study of the development or acquisition of a business appropriate to the objectives and resources of the individual entrepreneur.

BUSINESS LAW (B LAW)

400. REAL ESTATE LAW (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

*398G. ACCELERATED BUSINESS LAW (3) Social control through law; courts; policies underlying individual rights; negotiable and nonnegotiable contractual rights in society. Open to graduate students only.

BUSINESS LOGISTICS (B LOG)

412. TRANSPORT PLANNING ANALYSIS (3)

420. URBAN TRANSPORTATION (3)

430. TRANSPORT PROBLEMS (3)

440. LOGISTICS SYSTEMS ANALYSIS (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

538. LOGISTICS SYSTEMS MANAGEMENT (3) Control of the movement of goods; coordination of supply and demand in creation and maximization of time and place utility.

540. TRANSPORT POLICY (3) Role of transport in the economy. Transport systems elements, development, cost and pricing characteristics. Public control and public policies.

541. SOCIOECONOMIC ANALYSIS IN TRANSPORTATION (3) Role of transport in social and economic activity. Planning and coordination of transport systems. Designed for the traffic engineering program.

565. SEMINAR IN BUSINESS LOGISTICS (3-6)

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

FINANCE (FIN)

405. CAPITAL BUDGETING (3)

406. SECURITY ANALYSIS AND PORTFOLIO MANAGEMENT (3)

408. FINANCIAL MARKETS (3)

410. SPECULATIVE MARKETS (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

*398G. ACCELERATED FINANCIAL MANAGEMENT (3) Financial planning and forecasting; management of working capital, capital budgeting, and dividend policy; capital structure and valuation. Open to graduate students only.

*No graduate credit is given for this course.

504. PROBLEMS IN FINANCE (3-6) Planned individual projects involving library, laboratory, or field work.
506. PORTFOLIO THEORY AND POLICY (3) Rigorous examination and analysis of asset-holder behavior under conditions of risk and uncertainty.
508. ANALYSIS OF FINANCIAL MARKETS (3) Analysis of factors affecting price determination in financial markets.
510. CONTEMPORARY ISSUES IN FINANCIAL INSTITUTIONS (3) Critical investigation of problems of current interest in the market structure and internal operations of financial institutions.
531. FINANCIAL MANAGEMENT (3) An intensive examination of techniques available to aid the financial manager in decision making.
532. FINANCIAL DECISION PROCESSES (3) Financial decision making under uncertainty; positive and normative models and current issues in financial management.
541. SECURITY ANALYSIS (3) Discussion and application of analytical techniques in security valuation, including use of computers.
561. SEMINAR IN FINANCE (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

INSURANCE (INS)

400. ESTATE PLANNING (3)
401. FUNDAMENTALS OF PRIVATE PENSIONS (3)
410. COMPOUND INTEREST AND ANNUITIES-CERTAIN (3)
411. LIFE CONTINGENCIES I (3)
412. LIFE CONTINGENCIES II (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. INSURANCE THEORY AND PRACTICE (3) Insurance as an institution, a technique, a legal contract; its environment as a regulated industry.
504. PROBLEMS IN INSURANCE (3) Planned individual projects involving library, laboratory, or field work.
510. RISK MANAGEMENT (3) Analysis of managerial problems and responsibilities of risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.
596. INDIVIDUAL STUDIES (1-6)

INTERNATIONAL BUSINESS (I B)

501. THE INTERNATIONAL ENVIRONMENT (3) Conceptual approach analyzing and predicting influences of social, political, and economic norms and values upon diverse societies' managerial decision making.
502. INTERNATIONAL BUSINESS MACRO THEORY AND POLICY I (3) International economic trade and monetary tools are applied to current national policy issues to determine effects on international business operations. Prerequisite: Econ. 333.
503. INTERNATIONAL BUSINESS MICRO THEORY AND POLICY I (3) Analysis of the internal operations of multinational firms; design of optimal strategies of operation under varying environmental conditions.

504. SEMINAR IN INTERNATIONAL BUSINESS (3-6) Seminar in techniques applied to selected topics; market structures; capital budgeting, investment; comparisons of foreign norms and values; multinational organization characteristics.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

MANAGEMENT (MGMT)

410. OPERATIONS PLANNING AND CONTROL (3)

420. MANAGEMENT OF PERSONNEL SYSTEMS (3)

422. ADVANCED ORGANIZATION THEORY (3)

430. ADMINISTRATIVE MANAGEMENT (3)

432. SIMULATION OF MANAGEMENT SYSTEMS (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

*398G. ACCELERATED BUSINESS MANAGEMENT (3) The concepts of management and its decision processes including special attention to operations management.

510. OPERATIONS MANAGEMENT (3) Integration and application of decision making to operational and policy problems within the business firm.

515. DESIGN OF OPERATION OUTPUT SYSTEMS (3) Examination of research-based findings in operations management with a focus on the design and reliability of production systems.

516. OPERATIONS PLANNING AND CONTROL (3) Examination of research-based findings in operations management. The focus is on the operation and control of production systems.

517. MANAGEMENT OF SOCIO-TECHNICAL SYSTEMS (3) Surveys the economic, psychological, and sociological issues of work quality in terms of managerial implications and change strategies.

518. MANAGEMENT OF INVENTORY SYSTEMS (3) Analysis of business organizations as integrated inventory systems. Inventory theory and model building as tools for management decision making. Prerequisite: Q.B.A. 561 or Mgmt. 510 or I.E. 509.

519. SEMINAR IN OPERATIONS MANAGEMENT (3-6)

520. COMPLEX ORGANIZATIONS: STRUCTURE AND DESIGN (3) Analysis of theory, research and practice in the design of complex organizations. Relationships between organizational environments and structures are emphasized.

521. ORGANIZATIONAL POWER AND CONTROL (3) Theoretical and research emphasis on the bases and consequences of power and control in complex organizations.

523. ORGANIZATIONAL CHANGE: THEORY AND PRACTICE (3) Analysis of research, theory and practice in dynamics of organizational change. Research literature reviewed for evaluation of concepts and methods.

524. INTERPERSONAL RELATIONS IN ORGANIZATIONS (3) Development of skills and sensitivity for dealing with interpersonal relationships in complex organizations. Prerequisite: B.A. 550.

531. MANAGEMENT INFORMATION SYSTEMS (3) Information system theories and methods applied to administrative structures and management decisions in organizations.

540. PERSONNEL MANAGEMENT (3) Theory and practice of personnel management and analysis of personnel problems of relevance to all types of managers.

570. SEMINAR IN MANAGEMENT (3-6) Comparative analysis of research in the theories of the administrative sciences; relationships to business management practices.

*No graduate credit is given for this course.

575. FUTURE STUDIES AND MANAGERIAL PLANNING (3) Theory and research on the "future" dimensions of decision making and planning, particularly under conditions of rapid change.

576. PLANNING MODELS AND TECHNIQUES (3) Survey of models, concepts, and techniques appropriate to managerial long-range planning in complex organizations.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

MARKETING (MKTG)

424. MARKETING RESEARCH PROJECTS (3)

430. CONSUMER BEHAVIOR (3)

435. MARKETING AND PUBLIC POLICY (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

*398G. ACCELERATED MARKETING MANAGEMENT (3) Analyses of customer and market behavior, marketing systems, and competitive strategies; programming product, pricing, distribution, and promotion. Open to graduate students only.

500. MARKETING MANAGEMENT (3) Analysis of management's marketing problems including market analyses, pricing, channel of distribution, promotion, competition, product strategies, and marketing research.

510. PLANNING MARKET STRATEGY AND PROGRAMS (3) Development of marketing strategy for the firm and design of integrated product-service, promotion, and distribution programs utilizing systems analysis.

520. QUANTITATIVE ANALYSIS FOR MARKETING DECISIONS (3) Sales forecasting, new product proposals, media selection, and market testing analyzed using statistical and decision theory and other mathematical techniques.

530. CONSUMER AND MARKET BEHAVIOR (3) Buying behavior: concepts from the behavioral sciences, including utility, culture, life cycle, personality, attitudes, and learning.

540. MARKETING AND SOCIETY (3) Marketing problems of society, domestic and regional marketing systems; governmental policies toward marketing; social performance of marketing.

544. MARKETING THEORY (3) The development of marketing concepts, behavioral and other marketing theories; public policy and the role of marketing in societies.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

QUANTITATIVE BUSINESS ANALYSIS (Q B A)

404. SAMPLING IN BUSINESS OPERATIONS AND RESEARCH (3)

451. ANALYTICAL METHODS IN BUSINESS (3)

452. ANALYTICAL METHODS IN BUSINESS (3)

461. PROBABILISTIC MODELS IN BUSINESS (3)

490. ADVANCED BUSINESS STATISTICS (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

*No graduate credit is given for this course.

*398G. ACCELERATED BUSINESS STATISTICS (3) Basic characteristics of univariate and bivariate distributions, probability theory, introduction to estimation, tests of hypotheses, and time series analysis. Open to graduate students only.

500. SEMINAR IN BUSINESS STATISTICS (3-6)

501. ADVANCED BUSINESS STATISTICS (3)

510. STATISTICAL ANALYSIS FOR MANAGERIAL DECISION MAKING (3) Use of statistical methods for managerial decision making with emphasis on problem formulation, data analysis and interpretation, and business applications. Prerequisites: 3 credits each in undergraduate accounting, economics, and statistics.

521. QUANTITATIVE ANALYSIS FOR BUSINESS DECISIONS (3) Construction and use of quantitative methods in business decision making. Prerequisite: common requirements of M.B.A. program.

527. ANALYSIS FOR DECISION MAKING UNDER UNCERTAINTY (3) Topics in decision making under uncertainty including decision theory, Bayesian statistics, payoff function including utility theory and multi-attribute measures.

532. MANAGEMENT SYSTEMS SIMULATION (3) Application of computer simulation to the analysis and design of management decision systems. Design of simulation experiments in business research. Prerequisite: 3 credits of computer programming.

540. MATHEMATICAL PROGRAMMING (3) Nonlinear programming and geometric programming with emphasis on both theory and applications. Prerequisite: Q.B.A. 452.

550. SEMINAR IN MATHEMATICAL PROGRAMMING (3-6) Intensive treatment of theory and computational algorithms of mathematical programming; emphasis on operational application to complex management and business problems. Prerequisite: I.E. 510.

561. STOCHASTIC MODELS FOR MANAGEMENT DECISIONS (3) Introduction to stochastic processes in business organizations. Application of stochastic models to the conceptualization, analysis, and solution of management problems. Prerequisite: Math. (Stat.) 427.

570. MANAGEMENT SCIENCE: IMPLEMENTATION AND CONTROL (3) Development and application of management science models. Model formulation and specification, sensitivity analysis, problems encountered in implementation and control.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

REAL ESTATE (R EST)

400. URBAN LAND UTILIZATION (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

*No graduate credit is given for this course.

CERAMIC SCIENCE (CERSC)

GUY E. RINDONE, *In Charge of Graduate Programs in Ceramic Science*
201 Steidle Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bradt, Hummel, McKinstry, Newnham, Rindone, Spear, Stubican, and Tressler.

Graduate Faculty: Associate Member Halloran.

This program is one of the options in which a graduate student in the Department of Materials Science and Engineering can receive an advanced degree. In view of the wide field covered by ceramic science, the graduate courses may be selected with special emphasis in physical ceramics, chemical ceramics, or glass science.

The communication and foreign language requirement may be satisfied by (1) examinations in two languages — French examination administered by the ceramic science faculty and a second language examination by the appropriate language department — or (2) examination in one foreign language and either 6 credits of computer science or 6 credits of statistics, or 3 credits of computer science and 3 credits of statistics.

Special facilities exist for research in the areas of electroceramics, rheology, phase equilibria, solid state synthesis, mechanical properties, ferrite and ferroelectric studies, glass science, and high temperature reaction kinetics. Suitable preparation for graduate study in this program may be found in one of the material sciences such as ceramics or metallurgy, in engineering fields such as chemical or mechanical engineering, in the basic physical sciences, or in the earth sciences.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

CERAMIC SCIENCE (CERSC)

- 400. NONMETALLIC CRYSTAL CHEMISTRY (2-3) *Mr. Newnham*
 - 402. PRINCIPLES OF CERAMIC ENGINEERING (3)
 - 404. CERAMIC SEMINAR (1) *Mr. Hummel*
 - 406. RHEOLOGY AND FLUID PROPERTIES OF CERAMIC SYSTEMS (2) *Mr. Halloran*
 - 407. CERAMIC MATERIALS LABORATORY (2) *Mr. Halloran*
 - 408. THERMAL PROPERTIES OF CERAMIC MATERIALS (2) *Mr. Spear*
 - 409. THERMAL PROPERTIES OF CERAMIC MATERIALS LABORATORY (2) *Mr. Spear*
 - 410. PHASE RELATIONS IN CERAMIC SYSTEMS (3) *Mr. Hummel*
 - 411. PRINCIPLES OF CERAMIC PROCESSES (2) *Mr. Stubican*
 - 414. MECHANICAL PROPERTIES OF CERAMICS (3) *Mr. Bradt*
 - 415. PRINCIPLES OF GLASS TECHNOLOGY (3-4) *Mr. Rindone*
 - 420. REFRACTORIES (2-3) *Mr. Stubican*
 - 430. ELECTROCERAMICS (2) *Mr. Tressler*
 - 431. ELECTROCERAMICS LABORATORY (1) *Mr. Tressler*
 - 440. CARBON AND GRAPHITE (1) *Mr. Thrower*
 - 441. CERAMIC NUCLEAR MATERIALS (1) *Mr. Spear*
 - 496. INDEPENDENT STUDIES (1-12)
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- 500. SEMINAR IN CERAMIC SCIENCE (1-2 per term) Current developments in ceramic science and related fields. Required of all graduate students in ceramic science.
 - 501. SURFACE BEHAVIOR OF CERAMIC MATERIALS (2-4) Surface chemistry of ceramics. Rheology of ceramic powders, suspensions, and pastes.
 - 502. MECHANICAL PROPERTIES OF CERAMICS I (2) Theoretical considerations of the crystallo-

graphic and microstructural aspects of the elastic properties and fracture characteristics of ceramics. Prerequisite: Cer.Sc. 414 or E.Mch. 415.

503. USE OF PHASE EQUILIBRIA DATA IN CERAMIC SCIENCE (2-5) Phase equilibria in unary, binary, ternary, and other systems; applications in product development and in understanding behavior of ceramic materials. *Mr. Hummel*

504. SOLID STATE REACTIONS IN CERAMIC SYSTEMS (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452. *Mr. Stubican*

505. PHASE TRANSITION IN SOLIDS (2) Phase transitions will be studied in detail with respect to the crystal structure, free energy, and physical properties. *Mr. McKinstry*

506. MECHANICAL PROPERTIES OF CERAMICS II (2) Theoretical considerations of dislocation processes, diffusion phenomena, and microstructural effects on the deformation and creep of ceramic materials. Prerequisite: Cer.Sc. 502.

507. THERMAL PROPERTIES OF CERAMIC MATERIALS (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials.

508. DIELECTRIC AND MAGNETIC PROPERTIES OF CERAMIC MATERIALS (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials. *Mr. Newnham*

509. COMPOSITE MATERIALS (3) Manufacturing processes, atomic and molecular background, and topological relationships of macro- and microstructure to the physical properties of composites. *Mr. Tressler*

510. SEMINAR IN GLASS TECHNOLOGY (1-2 per term) Current developments in glass technology and related fields. *Mr. Rindone*

511. THE CONSTITUTION OF GLASS (2-3 per term) Historical and current concepts of the atomic structure of glass; relationship of structure to chemical and physical properties. *Mr. Rindone*

530. (G.M. 530) STRUCTURE, PROPERTIES, AND OCCURRENCE OF CLAY MINERALS (2-5) Structure analysis and identification of clay minerals; mineral transformation and behavior; occurrence, genesis, and petrography of fine-grained sediments.

596. INDIVIDUAL STUDIES (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

NOTE: Courses in the use of X-ray diffraction, electron microscopy, and the electron microprobe in ceramic science studies are listed under Materials Science.

CHEMICAL ENGINEERING (CH E)

LEE C. EAGLETON, *Head of the Department*
160 Merrell R. Fenske Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barton, Braun, Danner, Daubert, Duda, Eagleton, Engel, Jones, Kabel, Klaus, McCormick, and Ultman.

Graduate Faculty: Associate Members Peiffer, Tarbell, and Vannice.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, kinetics, catalysis, transport phenomena, unit operations and processes, optimization, polymer physics, bioengineering, process dynamics, mathematical modeling, applied chemistry, surface and colloid chemistry, petroleum technology, rheology, and lubrication. A foreign language is not required for the Ph.D. degree.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the

equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Applicants attending foreign universities are required to submit Graduate Record Examination scores. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

CHEMICAL ENGINEERING (CH E)

401. CHEMICAL PROCESS ENGINEERING (3)
 408. CHEMICAL ENGINEERING LABORATORY II (2)
 413. MASS TRANSFER OPERATIONS (4)
 414. KINETICS AND INDUSTRIAL CHEMISTRY (4)
 415. MATHEMATICAL MODELING IN CHEMICAL ENGINEERING (3)
 416. TECHNIQUES OF PROCESS DESIGN (3)
 420. CRYOGENIC ENGINEERING (3)
 422. MODERN PETROLEUM TECHNOLOGY — PROCESSES AND PRODUCTS (3)
 430. NUCLEAR CHEMICAL ENGINEERING (3)
 431. ADVANCED INDUSTRIAL CHEMISTRY APPLICATIONS (3)
 440. CHEMICAL ENGINEERING MATERIALS (3)
 441. POLYMER PROCESSING (3)
 445. PROJECTS IN CHEMICAL ENGINEERING (1-6)
 446. INTRODUCTION TO TRANSPORT PHENOMENA (3)
 448. ADVANCED MASS TRANSFER OPERATIONS (3)
 450. PROCESS DYNAMICS (3)
 453. THERMODYNAMICS FOR CHEMICAL ENGINEERS (3)
 455. CHEMICAL REACTOR DESIGN (3)
 460. CHEMICAL ENGINEERING (4)
 464. DESIGN OF CHEMICAL PLANTS (2)
 465. DESIGN PROJECTS IN CHEMICAL ENGINEERING (1-6)
 497. SPECIAL TOPICS (1-6)
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507. SIMULATION AND MODELING (3) Synthesis of subsystem and system models emphasizing the generality of the principles for application to diverse physical and chemical processes.
 508. PRINCIPLES OF INDUSTRIAL ORGANIC CHEMISTRY (3) Principles and practices of modern conversion processes in the manufacture of organic chemicals. Prerequisites: Chem. 31, 452. *Mr. Jones*
 509. HEAT TRANSFER APPLICATIONS (3) Advanced treatment of steady-state and transient conduction, convection, and radiation, with emphasis on numerical methods and design techniques. Prerequisite: an undergraduate course in heat transfer. *Mr. Daubert*
 516. METHODS OF PROCESS DESIGN (3) Survey of mathematical techniques of chemical process design with emphasis on economic choice and optimal decision making. *Mr. Engel*
 524. CHEMICAL ENGINEERING, APPLICATION OF THERMODYNAMICS (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.
 535. CHEMICAL REACTION ENGINEERING (3) Optimal design of batch and continuous chemical reactors and reactor batteries; effect of mixing on reactor operation. Prerequisite: Ch.E. 435.
 545. TRANSPORT PHENOMENA I (3) Momentum, heat, and mass transfer, steady and unsteady state, laminar and turbulent flow, coupling, analogies, chemical engineering applications.
 546. TRANSPORT PHENOMENA II (3) Momentum, heat, and mass transfer, steady and unsteady state, laminar and turbulent flow, coupling, analogies, chemical engineering applications.
 548. MULTISTAGE MASS TRANSFER OPERATIONS (3) Rigorous solution of complex problems in

distillation, extraction, and absorption including computer methods. Prerequisite: an undergraduate course in mass transfer. *Mr. Barton*

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

CHEMISTRY (CHEM)

JOSEPH A. DIXON, *Head of the Department*
152 Davey Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Allcock, Anderson, Ascah, Benkovic, Bernheim, Deno, Dixon, Fritz, Geoffroy, Gokel, Gold, Haas, Hamilton, Hecklen, Hisatsune, Horrocks, Jackman, Jordan, Jurs, Lampe, Lowe, Olofson, Richey, Risby, Rosenblatt, Shamma, Skell, Steele, Villafranca, Wartik, and Zook.

Graduate Faculty: Associate Member Matthews.

The Ph.D. program in chemistry provides students with a broad background in one of the areas of chemistry (analytical, biological, inorganic, organic, or physical) and intensive research experience culminating in the preparation of a formal thesis. The goal of the program is to prepare students for a variety of careers in academia, government, or industry. The general facilities are excellent, and the computer, cryogenic, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussions each Thursday at a departmental colloquium.

The department requires a knowledge of French, German, Japanese, or Russian as a condition for awarding either the M.S. or Ph.D. degree. Candidates who have taken and passed two undergraduate courses in French, German, Japanese, or Russian will be certified as having completed the communication and foreign language requirement. For the M.S. degree the student has the option of writing a thesis or a paper.

For admission, at least integral calculus plus one year's work in general physics, organic chemistry, physical chemistry, and either analytical or inorganic chemistry is normally required. Students who have appropriate course backgrounds and who present a 2.50 average in all undergraduate courses in chemistry, physics, and mathematics will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Prior to scheduling their first term programs, new students will take placement examinations in the areas of analytical, inorganic, organic, and physical chemistry. The information obtained from these tests will assist both the student and the adviser in making up a program best suited to the student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

- 400. CHEMICAL LITERATURE (1)
- 405. NUCLEAR AND RADIOCHEMISTRY (3)
- 408. (Cmp.Sc. 408) COMPUTER APPLICATIONS IN CHEMISTRY (3)
- 410. INORGANIC CHEMISTRY (2)
- 411. ADVANCED INORGANIC CHEMISTRY (2)
- 426. CHEMICAL INSTRUMENTATION (3)
- 427. INSTRUMENTAL ANALYSIS (2)
- 428. INSTRUMENTAL ANALYSIS (2)
- 429. INSTRUMENTAL ANALYSIS (2)
- 431. ORGANIC AND INORGANIC PREPARATIONS (3)
- 435. ADVANCED ORGANIC CHEMISTRY LABORATORY (3)
- 439. STRUCTURAL ANALYSIS OF ORGANIC COMPOUNDS (3)

448. SURFACE CHEMISTRY (2)
- *451-452. PHYSICAL CHEMISTRY (3 each)
453. ADVANCED PHYSICAL CHEMISTRY (3)
454. ADVANCED PHYSICAL CHEMISTRY (3)
455. PHYSICAL CHEMISTRY OF HIGH POLYMERS (3)
- *457. EXPERIMENTAL PHYSICAL CHEMISTRY (1-2)
- *458. EXPERIMENTAL PHYSICAL CHEMISTRY (1-2)
- †489. INTRODUCTION TO CHEMICAL RESEARCH (1-10 per term, maximum of 20)
500. SEMINAR IN CHEMISTRY (1 per term)
- 516-517. INORGANIC CHEMISTRY (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.
518. SPECIAL TOPICS IN INORGANIC CHEMISTRY (3 per term) Modern developments in specialized fields.
525. ANALYTICAL PROCESSES (3) Theoretical foundations and contemporary developments.
526. MODERN INSTRUMENTAL ANALYSIS (3)
527. SPECIAL TOPICS IN ANALYTICAL CHEMISTRY (2-12)
531. SPECIAL TOPICS IN ORGANIC CHEMISTRY (3-12) Prerequisite: Chem. 536.
534. CHEMICAL APPLICATIONS OF QUANTUM THEORY (3) A development of Molecular Orbital Theory up to the level of present-day usage in organic and inorganic chemistry.
- 535-536. ORGANIC REACTION MECHANISMS I AND II (3 each) Reaction mechanisms and their determination by kinetic and nonkinetic methods. Reactive intermediates. Prerequisite: Chem. 439.
537. SYNTHESIS IN ORGANIC CHEMISTRY (3) Theory and methods of directed syntheses, including stereospecific and stereoselective schemes; biologically inspired syntheses. Prerequisite: Chem. 536.
544. CHEMICAL THERMODYNAMICS (3) Development of thermodynamic theory with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.
545. STATISTICAL THERMODYNAMICS (3) The calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisites: Chem. 453 or 544, and Chem. 565.
560. TOPICS IN PHYSICAL CHEMISTRY (2-6)
563. CHEMICAL KINETICS (3) Theory and measurement of the rates of chemical reactions, molecular dynamics, and mechanisms of chemical reactions. Prerequisites: Chem. 453 or 544, and Chem. 565.
565. ATOMIC AND MOLECULAR STRUCTURE (3) Introduction to modern theoretical chemistry, spectroscopy, and structure of atoms and molecules.
566. QUANTUM CHEMISTRY (3) Theoretical calculations of electronic properties of atoms and molecules. Prerequisites: A.M. 405 and Chem. 565.
567. QUANTUM CHEMISTRY (3) A continuation of Chem. 566, including problems and theories of electron correlation. Prerequisite: Chem. 566.
571. POLYMER CHEMISTRY (3) The synthesis, reactions, and structure determination of high polymers.
589. STUDIES IN CHEMISTRY (1-9) Theoretical research, experimental research, or a critical survey of the literature in an area of chemistry.
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

*Graduate credit not allowed for students majoring in chemistry or chemical engineering.

†Graduate credit not allowed for students majoring in chemistry.

CIVIL ENGINEERING (C E)

RAYMOND E. UNTRAUER, *Head of the Department*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Aron, Barnoff, Cady, Crowley, Gotolski, Larson, Long, McDonnell, Nesbitt, Reed, Untrauer, Unz, Wang, West, and Willenbrock.

Graduate Faculty: Associate Members Anderson, Chadderton, Chan, Davinroy, Kibler, McClure, Miller, Mozingo, Regan, and Thomas.

Students may specialize in structures, hydraulics, hydrology, transportation engineering, traffic engineering, materials, construction, soils, and environmental engineering, or combinations of these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of one foreign language (French, German, or Russian) and proficiency in English. A thesis is required for the M.S. degree. An engineering report is required for the M.Eng. degree.

Candidates normally should be graduates from an accredited program in engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

See also Environmental Engineering.

CIVIL ENGINEERING (C E)

- 400. SEMINAR (1-3)
- 421. HIGHWAY ENGINEERING (3)
- 423. TRANSPORTATION SYSTEMS OPERATIONS (3)
- 424. CIVIL ENGINEERING MATERIALS (3)
- 431. CIVIL ENGINEERING CONSTRUCTION (3)
- 432. CONSTRUCTION PROJECT CONTROL (3)
- 446. ADVANCED SOIL MECHANICS (3)
- 447. STRUCTURAL ANALYSIS BY MATRIX METHODS (3)
- 448. ADVANCED STRUCTURAL DESIGN (3)
- 449. DESIGN OF PRESTRESSED AND REINFORCED CONCRETE STRUCTURES (3)
- 451. ADVANCED HYDROLOGY (3)
- 452. WATER RESOURCES AND COMPUTATIONS (4)
- 462. OPEN CHANNEL HYDRAULICS (3)
- 465. RIVER AND WATERWAYS ENGINEERING (3)
- 471. ENVIRONMENTAL SANITATION (3)
- 472. WATER POLLUTION CONTROL PROCESSES (3)
- 473. WATER QUALITY MANAGEMENT (3)
- 474. MANAGEMENT OF WATER POLLUTION CONTROL PROCESSES (3)
- 476. SOLID WASTE MANAGEMENT (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 500. SEMINAR IN CIVIL ENGINEERING (1-6) Reports on research and special topics. Course may be continued in subsequent terms.
- 501. CIVIL ENGINEERING PROJECTS (3-10) Investigation or design projects in structures, transportation, hydraulics, or civil engineering materials.

511. **ENGINEERING SOIL CHARACTERISTICS (3)** Physical and chemical factors in soil which influence their engineering properties of strength, deformation, permeability, and soil stabilization. Prerequisite: C.E. 44.
512. **APPLIED SOIL MECHANICS (2-5)** Soil classification by type of clay minerals and profile development; aerial photographic interpretation of soils and applications to site selection for dams, highways, and airports. Prerequisites: C.E. 44 and 3 credits of geological sciences.
513. **SOIL EXPLORATION AND ANALYSIS (3)** Laboratory evaluation of parameters used in modern soil mechanics. Involves techniques of soil testing, test limitations, sampling influences, technical reports. Prerequisite: C.E. 44.
518. **LAND USE AND TRANSPORTATION MODELS (3)** The urban planning process; transportation models; economic, residential, industrial retail and public sector submodels; integrated models; simulation models; evaluative models. Prerequisite: competence in computer applications and transportation principles. Prerequisite: 3 credits of computer science.
519. **TRAFFIC ADMINISTRATION AND FINANCE (2)** Organization and administration of traffic engineering at various levels of government; leaders in the highway transportation field are guest lecturers.
520. **PAVEMENT DESIGN (3)** Fundamental principles; properties of pavement components; design tests; design of flexible pavements; design of rigid pavements; pavement evaluation and strengthening. Prerequisites: C.E. 24, C.E. 44.
521. **TECHNIQUES OF TRANSPORTATION ANALYSIS (2-4)** Transportation functions, travel patterns, basic analytical methods in the planning content. Prerequisite: 3 credits of computer science.
522. **HIGHWAY OPERATIONS (2)** Theory and application of traffic controls, including functional operations of traffic signals, systems, and networks; the design of highway lighting. Prerequisite: C.E. 423.
523. **URBAN TRANSPORTATION PLANNING, TECHNOLOGY, POLICY, AND ADMINISTRATION (2-4)** Characteristics of urban areas, the urban transportation planning process, present and future urban transportation systems, urban transportation policy and administration. Prerequisite: C.E. 21.
524. **ADVANCED PROBLEMS IN CIVIL ENGINEERING MATERIALS (2-6)** Study, in the literature and by laboratory investigation, of selected topics on field-controlled civil engineering materials. Prerequisite: C.E. 424.
525. **AIRPORT PLANNING AND DESIGN (3)** Aircraft characteristics; aeronautical demand; site selection; airport configuration; capacity analysis; design of landing and terminal areas. Prerequisite: C.E. 21.
526. **TRANSPORTATION DESIGN-IMPACTS INTERACTION (3)** Transportation facilities with specific consideration of impact of such facilities on nontransport considerations; interaction of design criteria and impacts. Prerequisite: C.E. 423.
527. **ANALYSIS OF TRAFFIC FLOW OPERATIONS (3)** Vehicular flow characteristics, passengers and freight at transportation terminals, links and networks—particularly the relationship with operations and design. Prerequisite: C.E. 423.
529. **HIGHWAY GEOMETRIC DESIGN (3)** Principles of road and parking terminal design with emphasis on operations; highway planning related to alternate solutions of design problems. Prerequisites: C.E. 423, 522.
539. **APPROXIMATE METHODS OF STRUCTURAL ANALYSIS (3)** Newmark's method, finite difference method, and finite element method applied to problems in structural and soil engineering. Prerequisite: C.E. 40.
540. **STRUCTURAL ANALYSIS BY CLASSICAL METHODS (3)** Analysis of continuous trusses and beams, frames, arches, grids, curved beams, suspension systems, and space frames. Prerequisite: C.E. 40.
541. **STRUCTURAL ANALYSIS (3)** Analysis of continuous beams and frames, grids, slabs, shells and three-dimensional structural and soils problems by finite element methods. Prerequisite: C.E. 447.

544. **REINFORCED CONCRETE STRUCTURES (3)** Working stress, ultimate strength, and limit design; test behavior of beams, columns and slabs. Prerequisite: C.E. 41.
545. **DESIGN OF METAL STRUCTURES (3)** Steel, aluminum members; flexible connections; composite, hybrid, prestressed beams; tension-field beams; buckling; plastic analysis, design; test data; timber design. Prerequisite: C.E. 342.
546. **THIN CONCRETE STRUCTURES (3)** Design of thin concrete structures including slabs, folded plates, and shells. Prerequisite: C.E. 41.
548. **STRUCTURAL DESIGN FOR DYNAMIC LOADS (3)** Dynamic behavior of structural systems of one and more degrees of freedom; earthquake, blast-resistant analysis, and design of structures. Prerequisites: E.Mch. 12 and C.E. 40.
550. **ENGINEERING CONSTRUCTION MANAGEMENT (3)** Management fundamentals for construction contracting; organization, project planning, scheduling and control, bonding and insurance, labor legislation and regulation, cost and control. Prerequisite: C.E. 431.
551. **HYDROLOGIC INVESTIGATIONS (2-8)** Application of hydrologic principles and techniques to a specific project. Prerequisite: C.E. 451 or 452.
552. **HYDROLOGIC PROCESSES AND CYBERNETICS (3)** Application of cybernetic concepts in electronic computer simulation of the hydrologic process-components: infiltration, precipitation, evapotranspiration, and overland flow. Prerequisite: C.E. 51 or 452.
553. **PLANNING MULTIPURPOSE HYDROLOGIC SYSTEMS (3)** Study of multipurpose hydrologic schemes within a social, economical, and political framework. Prerequisite: C.E. 451 or 452; Econ. 14.
554. **URBAN HYDROLOGY (3)** Several hydrograph methods. Design storm and IUH application; airport drainage; flood plains; impact of urbanization upon groundwater and sediment. Prerequisite: C.E. 451 or 452.
560. **DIMENSIONAL ANALYSIS AND THEORY OF MODELS (3)** Principles of dimensional analysis and similitude with engineering applications primarily to problems in hydromechanics. Prerequisite: C.E. 61.
564. **HYDRAULIC ENGINEERING DESIGN (3)** Design and analysis of selected units of a typical hydraulic engineering project. Prerequisite: C.E. 62.
570. **PHYSICAL CHEMICAL TREATMENT PROCESSES I (2)** The theory of physical-chemical processes used in the treatment of potable water and municipal and industrial wastewaters. Prerequisite: C.E. 472.
571. **PHYSICAL CHEMICAL TREATMENT PROCESSES II (3)** The theory of physical-chemical processes used in the treatment of potable water and municipal and industrial wastewaters. Prerequisite: C.E. 472.
572. **BIOLOGICAL TREATMENT PROCESSES (2)** The theory of biological processes used in the treatment of municipal and industrial wastewaters. Prerequisite: C.E. 472.
573. **PROBLEMS IN ENVIRONMENTAL POLLUTION CONTROL (3-9)** Investigations, analyses, and reports on current topics in environmental pollution control. Prerequisites: C.E. 472 or 473 or 476 or M.E. 470.
574. **LABORATORY ANALYSES IN WATER QUALITY CONTROL (3)** Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control. Prerequisite: Chem. 14.
575. **INDUSTRIAL WASTE TREATMENT (2)** Surveys and data analysis; use of unit processes to meet regulatory agency requirements; disposal of gaseous and solid residues. Prerequisite: C.E. 472.
577. **TREATMENT PLANT DESIGN (1-6)** Design of works for the treatment of water and wastewater for municipalities and industries. Prerequisites: C.E. 472 and 3 credits in hydraulics.
579. (Micrb. 529) **AQUATIC MICROBIOLOGY (3)** Ecology and physiology of microorganisms of

inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.

580. STREAM AND ESTUARINE ANALYSIS (3) Quantitative assessment of advection, reaction, and dispersion processes in polluted waters; reaeration theory; eutrophic systems; analog simulation. Prerequisite: C.E. 472.

CLASSICS (CLASS)

ARCHIBALD ALLEN, *Head of the Department*
109 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty: Senior Member Carrubba.

Graduate Faculty: Associate Members Allen and Donlan.

The master's degree in classics is intended either as a terminal degree which (combined with the appropriate courses in educational theory and technique) equips students to teach at the elementary or secondary school level, or as preliminary to further graduate study at the doctoral level. The program allows specialization in either Latin or Greek but not to the exclusion of the other language. Although 18 undergraduate credits in some combination of Latin and Greek are the normal minimum requirements for admission, candidates can be admitted with deficiencies in the languages if these are compensated by training in ancient history, civilization, or archaeology. The required 2.50 grade-point average in junior-senior courses, normally considered a minimum for admission, will also be waived in special cases.

Of the 30 graduate credits required for the M.A., 6 may take the form of a supervised thesis. Candidates who choose not to submit a thesis must schedule 6 additional credits of course work. Besides the courses listed below, offered by the Department of Classics, candidates may schedule up to 9 credits in appropriate related subjects — such as ancient history, ancient philosophy, art history, or linguistics — offered by the respective departments. The comprehensive examination comprises a translation paper in either Latin or Greek, an essay exam in three areas of the student's choice in Greek and Latin literature, and a reading examination in a modern language (normally French or German).

GREEK (GREEK)

401. INTRODUCTORY READINGS IN GREEK LITERATURE (3)

420. THE GREEK HISTORIANS (3)

421. GREEK TRAGEDY (3)

422. GREEK COMEDY (3)

425. HOMER (3)

430. THE GREEK PHILOSOPHERS (3-9)

431. PLATO (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

507. PROBLEMS IN GREEK ARCHAEOLOGY (3-9)

509. GREEK SEMINAR (3-9)

517. GREEK RESEARCH (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

LATIN (LATIN)

401. INTRODUCTORY READING IN LATIN LITERATURE (3)

402. LATIN LITERATURE OF THE REPUBLIC (3-9)

- 403. LATIN LITERATURE OF THE AUGUSTAN AGE (3-9)
- 404. LATIN LITERATURE OF THE EMPIRE (3-9)
- 436. THE TEACHING OF LATIN (3)
- 437. LATIN PROSE COMPOSITION (3-6)
- 461. (Ling. 461) HISTORY OF THE LATIN LANGUAGE (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

500. LATIN LITERATURE (3-9) Readings in the major forms of Latin literature; content varies; course may be repeated.

501. ROMAN RELIGION AND PHILOSOPHY (3) Development of religious concepts at Rome from primitive Italic origins to the advanced forms that culminated in Roman Stoicism. Prerequisites: two 400-level courses in Latin.

510. LATIN SEMINAR (3-6)

518. LATIN RESEARCH (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

*CLASSICS (CLASS)

- 405. STUDIES IN GREEK MYTHOLOGY (3)
- 408. GREEK RELIGION AND MODERN MAN (3)
- 410. CLASSICAL EPIC (3)
- 411. CLASSICAL DRAMA (3)
- 412. CLASSICAL HISTORIANS (3)
- 496. INDEPENDENT STUDIES (1-12)

500. INTRODUCTION TO CLASSICAL SCHOLARSHIP (1-6) Lectures on the methods and materials of classical scholarship. To be scheduled by graduate students in their first term and as necessary thereafter.

504. TOPOGRAPHY OF ANCIENT ROME (3) Lectures and readings on physical development of the ancient city of Rome from earliest habitation to time of later empire.

597. SPECIAL TOPICS (1-6)

COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (CSP D)

GORDON D. BROWN, *In Charge of Graduate Programs in Community Systems Planning and Development*

S-210 Henderson Human Development Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Brown, Bullington, Freeman, Gamm, Gunter, Hunt, Katkin, Mann, Miller, Raffel, Ritti, Vallance, Woolley, and Young.

Graduate Faculty: Associate Members Ackroyd, Eisele, Ellis, Fisher, Fox, Guttenplan, Hill, Hussey, Hyman, Kramer, Mayers, Meyer, and Price.

This interdisciplinary program provides instruction in content and research methods relating to the coordinated planning, development, administration, and evaluation of a range of community services

*The readings are in English; knowledge of Greek and Latin is not required.

in the three professional areas of health and medical care services, justice services, and community social services.

The aim of the program is to build the knowledge base and skills necessary to develop policies and programs for the effective delivery of human services to individuals and communities. Graduates of the program will be able to identify major community subsystems and recognize community problems and dysfunctions, expressing their relative seriousness in terms of economic and social costs. Graduates will have skill in working with members of the community and with community institutions to develop ways of coping with such problems and to facilitate the creation of interventions which will improve the quality of life. In addition, they will have the skills necessary to evaluate the effectiveness of these interventions.

The Ph.D. program prepares professionals, researchers, and teachers with the necessary conceptual and technical skills to identify and analyze elements of human service systems and to develop, implement, and evaluate programs designed to improve the quality of life. Ph.D. students will develop considerable understanding of all human service systems and might elect to develop a master's level competency in one of the professional areas represented in the program. The communication requirements for the Ph.D. can be satisfied by demonstration of proficiency through examination in a foreign language or a set of computer languages. The M.S. program will prepare individuals for professional-level work in health planning and administration, administration of justice, or community social services. Career opportunities include administration and planning positions in hospitals and health facilities, community mental health, social services, criminal justice planning agencies, courts, and corrections programs. A thesis is required for the M.S. degree.

Preference will be shown to applicants who have a broad background in the social sciences. Proficiency in quantitative skills such as mathematics and statistics is also desirable. In general, a 3.00 junior-senior average is expected of applicants, but consideration will be given to prior graduate education and professional work experience.

Special research and training facilities include the Institute for the Study of Human Development, the University Computation Center, and a simulation laboratory.

COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (CSP D)

501. **HEALTH CARE ORGANIZATION (3)** Examination of health systems, organization, financing, and evaluation; trends, problems, and issues.

510. **HEALTH PROBLEM ANALYSIS (3)** Logic of empirical inquiry in study of community problems in health. Integration of theory and practice, technical data and values.

521. **VALUES AND GOALS IN THE ADMINISTRATION OF JUSTICE (3)** The justice system from perspective of clientele, service personnel, and the system. Meeting service requirements in community and institutional settings.

523. **ISSUES AND TRENDS IN THE DEVELOPMENT OF SOCIAL WELFARE SERVICES (3-6)** Examination of selected issues affecting the development of social welfare functions and services.

532. **INTERFACE PROBLEMS OF COMMUNITY SERVICE SYSTEMS (3)** Exploration of consequences of policy decisions and action in one or more social service systems on other community systems.

533. **BEHAVIORAL ASSUMPTIONS AND STRATEGIES IN THE PROCESS OF PLANNED CHANGE (3)** A general systems approach to the assumptions beneath various social problem strategies and consequences associated with each intervention-set.

534. **FORECASTING METHODS AND SOCIAL POLICY PLANNING (3)** Analysis of predictive methods for forecasting social change. Prerequisites: Econ. 405, Stat. 200.

590. **COLLOQUIUM (1-3)**

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

COMPARATIVE LITERATURE (C LIT)

ARTHUR O. LEWIS, *In Charge of Graduate Programs in Comparative Literature*
105 Sparks Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Begnal, Carrubba, Ebbinghaus, Frank, Kopp, Lewis, Lima, Walden, Ward, Weintraub, and West.

Graduate Faculty: Associate Members Balaban, Eckhardt, Grecco, Hale, Knight, and Peavler.

Programs of study combine a core of comparative literature courses with courses in several national literatures (two for the master's degree and three for the doctoral degree) according to the student's interests. These programs can be designed to concentrate on such topics as genres, themes, periods, movements, folklore, criticism, the influence of literary works, and the relationships among national literatures and between literature and other disciplines.

Requirements for the M.A. degree include (1) 9 credits in comparative literature (3 credits of which must be C.Lit. 501), 9 credits in one national literature, and 6 credits in a second national literature; (2) proficiency in the languages of the two literatures (one of which may be English); (3) a written comprehensive examination based on a reading list; and (4) 6 thesis credits.

Students with a 3.00 junior-senior average and appropriate course backgrounds (including preparation in a foreign language) will be considered for admission to the master's program. Exceptions may be made for students with special backgrounds and abilities.

Requirements for the Ph.D. degree include (1) 9 credits in comparative literature (C.Lit. 501, 502, and 503, unless these have been part of the M.A. degree program) and at least 21 credits in either a concentration in national literatures or a concentration in a period, genre, theme, or area study; (2) an oral candidacy examination; (3) proficiency in the languages of three literatures studied (one of which may be English); (4) a written comprehensive examination based on a reading list; and (5) a thesis.

Students holding or completing a master's degree in an appropriate field, and prepared to work in three national literatures, will be considered for admission to the doctoral program.

COMPARATIVE LITERATURE (C LIT)

400. SENIOR SEMINAR IN COMPARATIVE LITERATURE (3)
401. WESTERN LITERATURE I (3) *Mrs. Eckhardt and Mr. Knight*
402. WESTERN LITERATURE II (3) *Messrs. Knight and Condee*
403. WESTERN LITERATURE III (3) *Messrs. Begnal and Peavler*
407. LITERATURE RELATING TO THE SOUTH SEAS (3) *Mr. Martin*
408. HEROIC EPIC AND SONG (3) *Messrs. Bayard and Thigpen*
422. AFRICAN DRAMA (3) *Mr. Hale*
423. AFRICAN NOVEL (3) *Mr. Hale*
443. (Ger. 443) LITERARY RELATIONS OF GERMANY WITH ENGLAND AND AMERICA (3-9)
Messrs. Kopp and Lewis
470. OLD MASTERS OF THE MODERN NOVEL (3) *Mr. Begnal, Miss Ward*
480. INTRODUCTION TO FOLKLORE (3) *Mr. Thigpen*
486. TRAGEDY (3) *Messrs. Grecco and Lima*
487. COMEDY (3) *Messrs. Knight and Lima*
488. (Engl. 488) MODERN CONTINENTAL DRAMA (3) *Mr. Grecco*
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. SEMINAR IN COMPARATIVE LITERATURE (3-6)
501. COMPARATIVE METHOD IN LITERARY STUDIES (3) Bibliography, research methods, and studies in comparative literature. *Mrs. Eckhardt and Miss Ward*
502. COMPARATIVE CRITICISM I: CLASSICAL TO NEOCLASSICAL (3) Issues in literary criticism from Plato and Aristotle to the mid-eighteenth century. *Miss Ward*

503. COMPARATIVE CRITICISM II: ROMANTIC TO CONTEMPORARY (3) Principles and theories of literary criticism from eighteenth- and nineteenth-century beginnings to twentieth-century expansion and application. *Miss Ward*
508. NORSE AND GAELIC SAGAS (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to background, development, themes, and characteristics. *Messrs. Bayard and Ebbinghaus*
570. FORCES IN CONTEMPORARY EUROPEAN LITERATURE (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *Mr. West*
588. TWENTIETH-CENTURY DRAMA (3) The comparative analysis of major plays of the twentieth century. *Messrs. Grecco and Lima*
593. (Engl. 593) ANGLO-AMERICAN FOLK SONG (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present. *Mr. Bayard*
596. INDIVIDUAL STUDIES (1-6)

COMPUTER SCIENCE (CMPSC)

PATRICK C. FISCHER, *Head of the Department*
303 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Culk, deMaine, C. Fischer, P. Fischer, Goldstine, D. Johnson, and Laird.

Graduate Faculty: Associate Members Downey, Frederickson, Gonzalez, Gudes, Heller, Irwin, Ja'Ja', G. Johnson, Robertson, Seiferas, Spirn, and Wotschke.

The department offers courses and is prepared to direct research in a variety of subfields of computer science, including data bases and information retrieval, foundations of computer science, analysis of algorithms, computational complexity, formal language theory, operating systems, and numerical analysis. The Computation Center has modern facilities available for research and instruction. The department operates a Computer Systems Laboratory for instruction.

Admission to the M.S. program without deficiency requires that an applicant should have completed at least 9 credits of computer science at the advanced undergraduate level from the areas of data structures, programming languages and compiler design, computer organization and operating systems, numerical analysis, and language and automata theory. In addition, the student is expected to have mathematics training which includes calculus, linear algebra, and some discrete mathematics.

The M.S. candidate must satisfactorily complete the requirements of the Graduate School. In addition, at least 12 of the required 500-level credits shall be regular courses in the Department of Computer Science meeting certain distribution requirements described in the departmental brochure, *Graduate Study in Computer Science at Penn State*. The nonthesis option is available for the M.S. degree. The candidate may also be required to demonstrate proficiency in the design and implementation of computer programs or computer-related systems, or both.

The Ph.D. degree is primarily a research degree and is conferred on the basis of original work and high academic achievement in computer science. In order to be accepted as a candidate the student must pass a written candidacy examination. The communication and foreign language requirement for the Ph.D. degree may be satisfied by a proficiency in one foreign language (French, German, or Russian). These and additional requirements are detailed in the departmental brochure cited above.

Students with at least a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for

students with special backgrounds, abilities, and interests. The department requires scores on the Graduate Record Examination Aptitude Test from all applicants.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D and M.S. degrees (see p. 238).

COMPUTER SCIENCE (CMPSC)

- 402. INTRODUCTION TO COMPUTER PROGRAMMING (3)
 - 404. INFORMATION STRUCTURES (3)
 - 408. (Chem. 408) COMPUTER APPLICATIONS IN CHEMISTRY (3)
 - 410. INTRODUCTION TO COMPUTER SYSTEMS (3)
 - 411. SYSTEMS ORGANIZATION AND PROGRAMMING (3)
 - 420. THE STRUCTURES OF PROGRAMMING LANGUAGES (3)
 - 430. COMBINATORICS AND GRAPH THEORY (3)
 - 440. INTRODUCTION TO DATABASE MANAGEMENT SYSTEMS (3)
 - 442. ADVANCED PROGRAMMING AND JOB CONTROL LANGUAGE (3)
 - 444. SYSTEMS AND PROGRAM DESIGN IN EDP (3)
 - 453. (Math. 453) NUMERICAL COMPUTATIONS (3)
 - 454. (Math. 454) MATRIX COMPUTATIONS (3)
 - 468. MATHEMATICAL MACHINE THEORY (3)
 - 491. COMPUTER PROJECTS (1-12)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
500. THEORY OF AUTOMATA (3) The structure of finite automata and sequential machines including characterization theorems, minimization problems, state identification experiments, and decomposition theory. Prerequisite: Cmp.Sc. 468.
510. STRUCTURE OF ARTIFICIAL LANGUAGES (3) Structure of problem-oriented languages; syntactical description, algorithms for translation, list structures, string manipulation, formula manipulation, relation to linguistics. Prerequisites: Cmp.Sc. 420, 468.
511. OPERATING SYSTEMS (3) Concurrent processes, synchronization and deadlock, scheduling models, queueing models, memory management, and security. Prerequisites: Cmp.Sc. 411; Stat. (Math.) 418.
530. MACHINE INTELLIGENCE AND HEURISTIC PROGRAMMING (3) Methods for making machines behave intelligently; problem solving, theorem proving, game playing, question answering, learning, induction; specialized languages and data structures. Prerequisite: Cmp.Sc. 420.
534. ALGORITHM DESIGN AND ANALYSIS (3) Data structures and programming techniques useful in the design of efficient algorithms; algorithm analysis; computational complexity. Prerequisite: Cmp.Sc. 404.
535. THEORY OF GRAPHS AND NETWORKS (3) Theory and applications of graphs including structure of graphs, network analysis, and algorithms for computer solution of graph-theoretic problems. Prerequisite: Cmp.Sc. 430.
537. (B.A. 537) MANAGEMENT INFORMATION SYSTEMS DESIGN (3) Cost, value, and technical considerations in analysis and design of information systems whose purposes are to aid decision making in organizations.
540. INFORMATION PROCESSING SYSTEMS (3) Data structures and data processing; information retrieval systems. Prerequisite: Cmp.Sc. 411.
545. INFORMATION RETRIEVAL (3) Input-output, design, implementation, evaluation, global memories, and comparison of information retrieval systems. Prerequisite: Cmp.Sc. 540.
551. (Math. 551) NUMERICAL ALGEBRA (3) Zeros of polynomials; iterative solution of linear and nonlinear systems; sparse matrix techniques; eigenvalues and eigenvectors. Prerequisite: Cmp.Sc. 454 or Math. 441.

552. (Math. 552) INTRODUCTION TO APPROXIMATION THEORY (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 3 credits in computer science.
553. (Math. 553) NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS (3) Methods for initial value and boundary value problems. Stability and convergence analysis, automatic error control, and stiff systems. Prerequisites: Cmp.Sc. 453, Math. 431.
559. COMPUTABILITY AND RECURSIVE FUNCTIONS (3) Mathematical treatment of computability, recursive functions, Turing machines, unsolvable problems, recursive and recursively enumerable sets. Prerequisite: Cmp.Sc. 468.
564. (Math. 564) NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS (3) Methods of parabolic, hyperbolic and elliptic partial differential equations; finite difference and variational methods; splines, finite elements. Prerequisites: Cmp.Sc. 453, 454; A.M. 451 or Math. 405.
- 568-569. THEORY OF FORMAL LANGUAGES AND AUTOMATA (3 each) Generation and recognition of formal languages, grammars, Chomsky's hierarchy of languages, closure properties, characterization by automata, algebraic properties, complexity classification. Prerequisite: Cmp.Sc. 468.
579. (Math. 579) SPECIAL TOPICS IN NUMERICAL ANALYSIS (2-12)
590. COLLOQUIUM (1-3)
591. SPECIAL TOPICS IN COMPUTER SCIENCE (2-6)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

COUNSELOR EDUCATION (CN ED)

EDWIN L. HERR, *Head of the Division of Counseling and Educational Psychology*
201 Carpenter Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Baker, Britton, Herr, Horan, Hudson, Hyllbert, Keat, Kelz, and Swisher.

Graduate Faculty: Associate Members Bandt and Upcraft.

Professional preparation is offered at the master's level for school counselors (elementary and secondary), college counselors or persons entering college student personnel services, and rehabilitation counselors. Doctoral programs prepare candidates for positions of responsibility and leadership in these same areas, as well as in the education of counselors. Doctoral candidates must have a minimum of one year of work experience in their field.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a comprehensive knowledge of one foreign language and courses from other designated areas, or by options from designated areas selected to include competence in statistics, research design, computer application, or electronic data processing.

All candidates for graduate degrees in counselor education must present for admission at least 27 undergraduate credits of 3.00 or better, distributed among at least three of the following areas: economics, education, psychology, sociology, and physiology or anatomy.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Doctoral candidates should present at least a 3.33 average in all graduate study completed.

All candidates are expected to exhibit, in addition to academic competence, effectiveness in

interpersonal relations and in both written and oral communication. They must also evidence support of professional counseling activities and organizations.

A candidate for either a Ph.D. or a D.Ed. degree must earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree, preferably at the thesis planning and writing stage.

COUNSELOR EDUCATION (CN ED)

- 403. FOUNDATIONS OF GUIDANCE AND COUNSELING PROCESSES (3)
- 404. GROUP PROCEDURES IN GUIDANCE AND COUNSELING (3)
- 408. INTRODUCTION TO VOCATIONAL REHABILITATION (3)
- 409. MEDICAL INFORMATION FOR COUNSELORS (3)
- 410. REHABILITATION OF THE MENTALLY ILL (3)
- 412. REHABILITATION FACILITIES AND SERVICES OF PENNSYLVANIA (3)
- 413. REHABILITATION CASE RECORDING AND MANAGEMENT (3)
- 425. THE USE OF TESTS IN COUNSELING (3)
- 470. WORKSHOP IN STUDIES IN COUNSELOR EDUCATION (1-6)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. COUNSELING: THEORY AND METHOD (3) Theory and methods of counseling individuals whose problems of choice, decision, and adjustment fall within the normal range. Prerequisite: Cn.Ed. 403 or 408 or 551.
- 503. GUIDANCE SERVICES IN ELEMENTARY EDUCATION (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals. Prerequisite: Cn.Ed. 403.
- 504. GUIDANCE SERVICES IN SECONDARY EDUCATION (3) Nature and scope of guidance in secondary schools — services, models, and strategies; the counselor as an agent of change. Prerequisite: Cn.Ed. 403.
- 505. FOUNDATIONS OF COUNSELING INFORMATION (3) Accelerating change in economic, psychological, social, educational influences upon counselees. Utilization of information systems in effecting counselee change. Prerequisite: Cn.Ed. 403 or 408 or 504 or 551.
- 506. INDIVIDUAL ANALYSIS AND COUNSELING PROCEDURES (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing. Prerequisites: Ed.Psy. 451; Cn.Ed. 408 or 503 or 504.
- 507. COUNSELING PRACTICUM (1-6) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Cn.Ed. 506.
- 508. ORGANIZATION AND ADMINISTRATION OF GUIDANCE PROGRAMS (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: Cn.Ed. 506.
- 509. CONTRIBUTIONS OF PROFESSIONAL PERSONNEL TO VOCATIONAL REHABILITATION (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics; medical problems. Prerequisites: Cn.Ed. 403, 408.
- 511. SUPERVISED PRACTICUM IN REHABILITATION COUNSELING (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Cn.Ed. 403, 408.
- 512. PROFESSIONAL EXPERIENCE IN REHABILITATION COUNSELING (1-10) Supervised internship with responsibility for a regular case load. Prerequisites: Cn.Ed. 403, 409, 501, 507.
- 513. SUPERVISION OF COUNSELORS (3-9) Practical experience in supervising and evaluating work of counselors. Prerequisite: Cn.Ed. 507.
- 515. SEMINAR IN COUNSELING, GUIDANCE, AND REHABILITATION (1-9) Conferences and discussions designed to meet the need for special study of particular topics in counseling, guidance, and rehabilitation. Prerequisite: 9 credits in counselor education.

516. **EVALUATION OF PROJECTS IN SCHOOL GUIDANCE (2-6)** Implementation and evaluation of program development projects in cooperation with state or local guidance programs. Prerequisite: 15 credits in counselor education.
517. **ELEMENTARY SCHOOL COUNSELING INTERNSHIP AND SEMINAR (1 per term, maximum of 3)** Off-campus, supervised internships in elementary school settings with supplementary related topics, discussion, and skills training in on-campus seminars. Prerequisite: Cn.Ed. 503.
518. **SECONDARY SCHOOL COUNSELING INTERNSHIP AND SEMINAR (1 per term, maximum of 3)** Off-campus, supervised internships in secondary school settings with supplementary related topics, discussion, and skills training seminars. Prerequisite: Cn.Ed. 504.
551. **STUDENT PERSONNEL SERVICES (2-3)** Student personnel services in higher education; organization of student advisory programs; use of personnel data; cocurricular activities; student welfare.
553. **STUDENT PERSONNEL SERVICES PROGRAMMING (2-3)** Formulation of policies as guides to the student personnel service programs; integration of program elements; research; current problems and trends. Prerequisites: Cn.Ed. 551, Hi.Ed. 545.
555. **CAREER COUNSELING (3)** The examination of historical, legislative, and current models of career counseling and the development of pertinent individual and group techniques. Prerequisite: Cn.Ed. 505.
589. **PROBLEMS, PROJECTS, AND AREA STUDIES IN COUNSELOR EDUCATION (1-6)** Independent work in the study of topics in counselor education, or development of new curriculums, materials, or procedures for teaching.
591. **SEMINAR IN COUNSELING: HISTORY AND TRENDS (1)** Discussion of the history of guidance and counseling, emphasizing how the past has shaped the present and portends the future. Prerequisite: 9 credits in counselor education.
592. **SEMINAR IN COUNSELING: LEGAL AND ETHICAL CONCERNS (1-2)** Study and discussion of legal, ethical, and professional concerns of counselors; privileged communication, data banks, and privacy invasion. Prerequisite: 9 credits in counselor education.
593. **SEMINAR IN COUNSELING: PHILOSOPHY (1)** Study and discussion of such philosophical foundations of counseling as phenomenology, idealism, realism, existentialism, and daseinanalytic, theological, and other contemporary thoughts. Prerequisite: 9 credits in counselor education.
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

CURRICULUM AND INSTRUCTION (C I)

CAROL A. CARTWRIGHT, *In Charge of Graduate Programs in Curriculum and Instruction*
155 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Alessandro, Askov, Bell, Bixby, Bliesmer, Brewer, Cartwright, V. Dupuis, Dwyer, Fagan, Fowler, Golub, Heilman, Heimer, Hermanowicz, Madsen, Searles, Shernick, Short, Shrigley, Szabo, Trueblood, Welliver, Withall, F. Wood, Yawkey, and Zaffroni.

Graduate Faculty: Associate Members Alfke, M. Dupuis, Hogg, Johnson, Koble, Marbach, Nelson, Nicely, Sharp, and N. Wood.

This program provides advanced professional preparation in the special areas of curriculum and supervision, elementary and early childhood education, industrial arts education, instructional media education, language education, mathematics education, science education, and social studies education. Candidates for the Ph.D. and D.Ed. degrees must meet all requirements, described in the earlier sections of this catalog. To meet residency requirements, the Ph.D. candidate must spend at least three consecutive terms enrolled as a full-time student at the University Park Campus. The D.Ed. candidate

must spend at least three of any five consecutive terms enrolled as a full-time student at the University Park Campus.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages.

Candidates for the D.Ed. degree with a minor in curriculum and instruction must take a minimum of 15 course credits approved in advance by the person in charge of graduate programs in curriculum and instruction. Candidates for the M.Ed. degree with a minor in curriculum and instruction must take a minimum of 6 course credits approved in advance.

For admission to the professional degrees of M.Ed. and D.Ed., teaching or equivalent experience and at least 18 credits in education are recommended. Students with a 2.75 junior-senior average and with appropriate course and professional backgrounds will be considered for admission, subject to the limitation of program facilities.

CURRICULUM AND SUPERVISION (C & S)

- 400. INTRODUCTION TO RESEARCH LITERATURE (3)
 - 401. MEASUREMENT AND EVALUATION OF INSTRUCTION, K-12 (3)
 - 402. PROFESSIONAL TERM IN ELEMENTARY EDUCATION (12)
 - 403. PRACTICUM IN STUDENT TEACHING (10)
 - 404. PROFESSIONAL ORIENTATION OF THE ELEMENTARY TEACHER (3)
 - 470. WORKSHOP IN SELECTED STUDIES IN CURRICULUM (1-6)
 - 471. WORKSHOP IN SELECTED STUDIES IN SUPERVISION (1-6)
 - 472. SCHOOL PROGRAMS FOR YOUNG CHILDREN II (3)
 - 473. SECONDARY EDUCATION IN AMERICA (3)
 - 474. (I.F.S. 474) EDUCATIONAL FOCUS ON DEVELOPMENTAL CHILD CARE (3)
 - 490. (Human. 490) HUMANITIES FOR TEACHERS (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
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- 570. PROBLEMS SEMINAR FOR EXPERIENCED EDUCATORS (3) Historical, psychological, social, and economic factors influencing educational programs. Prerequisite: 12 credits in education and psychology.
 - 571. SEMINAR IN CONTEMPORARY ISSUES IN ELEMENTARY EDUCATION (1-3) Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisites: 6 credits in elementary education and teaching experience.
 - 572. ISSUES AND TRENDS IN EARLY CHILDHOOD EDUCATION (3) Research, experimental programs and emerging trends in early childhood education; relationships between educational experiences and later intellectual and emotional development. Prerequisites: C.&S. 472, Ed.Psy. 400.
 - 573. ORGANIZATION OF THE ELEMENTARY SCHOOL CURRICULUM (3) Principles underlying curriculum construction. Primarily for elementary education majors. Prerequisite: C.&S. 402 or teaching experience.
 - 575. ORGANIZATION OF THE SECONDARY SCHOOL CURRICULUM (3) Functions of laymen, pupils, teachers, supervisors, and administrators in secondary school curriculum construction. Prerequisites: 12 credits in education and psychology, and teaching experience.
 - 576. CURRICULUM THEORY K-12 (3) The analysis and use of the foundations which underlie models of curriculum design. Prerequisite: C.&S. 573 or 575.
 - 577. SEMINAR IN CURRICULUM RESEARCH (3) Seminar designed to meet the need for special study of particular research projects in elementary and secondary education. Prerequisite: 12 credits of graduate work in education.
 - 578. STANDARD WORKS IN CURRICULUM AND INSTRUCTION (3) Study of significant empirical, historical, evaluative, philosophical, and critical works having an impact on curriculum and instruction practice. Prerequisite: C.&S. 576.

579. **WORKSHOP IN CURRICULUM AND SUPERVISION (1-6)** For experienced teachers and supervisors involved in changing educational programs.
580. **SUPERVISION OF STUDENT TEACHERS (3)** A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education including at least 5 in methods.
581. **PRINCIPLES OF INSTRUCTIONAL SUPERVISION (3)** Social and institutional settings for instructional supervision; functions, activities, and practices of supervision; supervisory case studies.
582. **SYSTEMATIC OBSERVATION OF INSTRUCTION (3)** Construction and use of valid and reliable systematic observation systems used as a basis for classroom observation of instruction. Prerequisite: student teaching or teaching experience.
583. **INTERNSHIP IN CURRICULUM AND SUPERVISION (3-6)** Internship in schools or educational facilities where student is not employed, under supervision of graduate faculty in student's major area.
588. **PROBLEMS, PROJECTS, AND AREA STUDIES IN CURRICULUM AND INSTRUCTION (1-6)** Independent work in the study of topics in curriculum and instruction; development of new curricula, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of program chairman.

INDUSTRIAL ARTS EDUCATION (IA ED)

460. **PLANNING AND MANAGEMENT OF INSTRUCTIONAL RESOURCES (3)**
461. **CONSTRUCTION ACTIVITIES IN THE ELEMENTARY SCHOOL (3)**
462. **PROBLEMS IN INDUSTRIAL ARTS (2)**
464. **CURRICULUM AND INSTRUCTION: INDUSTRIAL STUDIES (3)**
465. **PREPROFESSIONAL EXPERIENCE IN INDUSTRIAL STUDIES (1-3)**
496. **INDEPENDENT STUDIES (1-12)**
497. **SPECIAL TOPICS (1-6)**
561. **HISTORY AND PHILOSOPHY OF INDUSTRIAL ARTS (2-3)** Historical developments and concurrent educational philosophies of industrial arts in American education.
562. **CURRICULUM DEVELOPMENT IN INDUSTRIAL ARTS EDUCATION (2-3)** Analysis of curriculum innovations in industrial arts and cognate fields; strategies for implementing curricular change; construction and assessment of curriculum materials. Prerequisite or concurrent: I.A.Ed. 561. Prerequisite: teaching experience.
563. **SUPERVISION AND ADMINISTRATION OF INDUSTRIAL ARTS EDUCATION (2-3)** How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisite or concurrent: I.A.Ed. 562. Prerequisite: teaching experience.
564. **EVALUATION IN INDUSTRIAL ARTS (2-3)** Construction of informal manipulative and written tests; use of standardized mechanical aptitude tests; construction and use of performance rating scales. Prerequisite: C.&S. 400 or 401.
568. **RESEARCH IN INDUSTRIAL ARTS (2-3)** Research techniques in industrial arts education. Prerequisite or concurrent: C.&S. 400.
569. **SEMINAR IN INDUSTRIAL ARTS (1-9)** Directed intensive study, investigation or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INSTRUCTIONAL MEDIA (INSTM)

411. **ORIENTATION TO INSTRUCTIONAL MEDIA (2)**
412. **PRODUCTION AND UTILIZATION OF GRAPHIC STIMULUS MATERIALS (3)**
413. **PRODUCTION OF EDUCATIONAL MOTION PICTURES (3)**
414. **TELEVISION IN EDUCATION (3)**
415. **SYSTEMATIC INSTRUCTIONAL DEVELOPMENT (3)**

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

511. ORGANIZATION AND ADMINISTRATION OF MEDIA IN SCHOOLS (3) Problems of providing instructional media in schools; the role of the media consultant in curriculum construction. Prerequisite: Inst.M. 411.

532. SURVEY OF MEDIA RESEARCH (3) Systematic study of media research in educational applications of television, still and motion pictures, graphic and simulated environments. Prerequisite: Ed.Psy. 400.

MATHEMATICS EDUCATION (MTHED)

420. TEACHING MATHEMATICS IN THE ELEMENTARY SCHOOLS (3)

421. TEACHING MATHEMATICS IN THE SECONDARY SCHOOLS (4)

422. INDIVIDUALIZING INSTRUCTION IN SCHOOL MATHEMATICS (3)

424. CONTEMPORARY ELEMENTARY SCHOOL MATHEMATICS PROGRAMS (3)

425. CONTEMPORARY SECONDARY SCHOOL MATHEMATICS PROGRAMS (3)

427. COMPUTERS AND THE TEACHING OF MATHEMATICS (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

520. ANALYSIS OF RESEARCH IN MATHEMATICS EDUCATION (3) Survey of the status of knowledge about mathematics learning and instruction, K-12; analysis of research procedures; instruments for evaluating research. Prerequisites: Mth.Ed. 420 or 421, 3 credits in statistics, and teaching experience.

521. STRATEGIES FOR RESEARCH IN MATHEMATICS EDUCATION (3) In-depth analysis of strategies for research in mathematics education; conditions for applying the scientific model; implications for research and development. Prerequisite: Mth.Ed. 520.

525. RESEARCH PARTICIPATION IN SCHOOL MATHEMATICS CURRICULUM CONSTRUCTION (3) Development of theoretical bases for the construction of instructional materials in mathematics, research participation in preparing and testing curriculum materials. Prerequisite: Mth.Ed. 521.

READING, COMMUNICATION, AND LANGUAGE EDUCATION (RCLED)

400. TEACHING READING IN THE ELEMENTARY SCHOOL (3)

401. METHODS OF TEACHING LANGUAGE ARTS IN ELEMENTARY SCHOOL (3)

402. TEACHING CHILDREN'S LITERATURE (3)

403. TEACHING ENGLISH IN THE SECONDARY SCHOOLS (4)

405. READING PROBLEMS IN THE SECONDARY SCHOOLS (2)

420. TEACHING READING AND LITERATURE TO ADOLESCENTS (3)

424. SEMINAR IN FOREIGN LANGUAGE AND BILINGUAL EDUCATION (3)

440. FUNDAMENTALS OF READING INSTRUCTION (3)

442. THE ELEMENTARY SCHOOL LANGUAGE ARTS PROGRAM (3)

443. TEACHING LANGUAGE AND COMPOSITION (3)

445. TEACHING ENGLISH IN BILINGUAL/DIALECTAL EDUCATION (3)

446. REMEDIAL READING IN THE CLASSROOM (3)

450. CONTENT AREA READING (3)

467. INTERGROUP STORYTELLING (3)

470. SELECTED STUDIES IN READING, COMMUNICATION, AND LANGUAGE EDUCATION (1-6)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

526. (Ed.Psy. 526) THE PSYCHOLOGY OF READING (3) Psychological principles underlying the process of reading and comprehending with application to instruction. Prerequisite: Ed.Psy. 421.

540. TEACHING READING: LINGUISTICS PERSPECTIVE (3) Examination of reading as language and

thought processes; contributions of linguistics, orthography, semantics, and syntax to instructional strategies. Prerequisites: undergraduate reading course and teaching experience.

541. CHILDREN'S LITERATURE RELATED TO ETHNIC AND SOCIAL ISSUES (3) Children's literature, K-12; study of literary symbolism, ethnic literature, and controversial issues; bibliotherapy, censorship, sex education through the trade book. Prerequisite: RCLEd.402.

542. ISSUES IN READING, COMMUNICATION, AND LANGUAGE EDUCATION (3 per term, maximum of 6) Issues in curriculum development and research in reading, communication, and language education, K-12, instructional materials analysis, and development. Prerequisites: RCLEd.403 or 405; and teaching experience.

543. RESEARCH IN THE TEACHING OF READING, COMMUNICATION, AND LANGUAGE EDUCATION (3 per term, maximum of 6) Cooperative study of problems and research findings in the teaching of reading, communication, and language education in American schools. Prerequisite: RCLEd.403 or 405; and teaching experience.

545. DIAGNOSTIC TESTING IN READING (3) Practicum in diagnosing reading difficulties, elementary and secondary levels; achievement, diagnostic, and capacity tests; informal inventories; genesis of reading problems. Prerequisite: RCLEd.440.

550. THEORY AND PRACTICUM IN REMEDIAL READING FOR ELEMENTARY STUDENTS (3) Supervised practicum with young children where remediation designs are analyzed, applied, and evaluated. Prerequisites: RCLEd.440 or equivalent teaching experience, and RCLEd.545.

551. THEORY AND PRACTICUM IN REMEDIAL READING FOR SECONDARY/ADULT LEARNERS (3) Supervised practicum work with secondary/adult/remedial students based upon theories and research concerning the reading problems of young adults. Prerequisite: RCLEd.550.

557. PRACTICUM: REMEDIAL PROCEDURES AND DIAGNOSIS (3-6) Advanced practicum; diagnostic testing and remedial instruction of more severe types of reading disability; newer and special materials and procedures. Prerequisite: RCLEd.545.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

SCIENCE EDUCATION (SCIED)

454. SCIENCE IN EARLY CHILDHOOD EDUCATION (3)

455. FIELD NATURAL HISTORY FOR TEACHERS (3)

456. TEACHING OF CONSERVATION OF NATURAL RESOURCES IN THE SCHOOLS (3)

457. TEACHING OF ENVIRONMENTAL EDUCATION IN THE SCHOOLS (3)

458. TEACHING SCIENCE IN THE ELEMENTARY SCHOOL (3)

459. TEACHING SCIENCE IN THE SECONDARY SCHOOL (4)

470. SELECTED STUDIES IN SCIENCE EDUCATION (1-6)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

556. THE SUPERVISION OF SCIENCE CURRICULUM (3) Supervision of elementary and secondary science teachers as they develop K-12 programs in the public schools. Prerequisites: 6 credits in science methods, 20 credits in science or equivalent, and teaching experience.

557. (Biol. 557) WORKSHOP IN THE BIOLOGICAL SCIENCES (3) Projects designed for teachers of biology in the secondary schools.

558. RESEARCH PROBLEMS IN SCIENCE TEACHING (3) Problems and research dealing with curriculum, materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sci.Ed. 458 or 459, and teaching experience.

559. ANALYSIS OF INSTRUCTION IN ELEMENTARY SCIENCE EDUCATION (3) Analysis of the history, issues, trends, and research in elementary science education. Prerequisites: teaching experience, 3 credits in elementary science methods, and 18 credits of science courses.

SOCIAL STUDIES EDUCATION (SS ED)

- 430. TEACHING SOCIAL STUDIES IN THE ELEMENTARY GRADES (2-3)
- 431. TEACHING SOCIAL STUDIES IN THE SECONDARY SCHOOLS (4)
- 432. THE SOCIAL SCIENCES IN THE SOCIAL STUDIES CURRICULUM (2-3)
- 470. ISSUES IN SOCIAL STUDIES EDUCATION (1-6)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

530. INSTRUCTIONAL PRACTICES IN THE SOCIAL STUDIES (3) Social studies innovations in the classroom, new programs, new materials, new methods, and evaluation. Prerequisite: one year of teaching experience.

531. PROBLEMS IN ELEMENTARY SCHOOL SOCIAL STUDIES (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources, and promising proposals. Prerequisites: 400-level course in social studies methods, and elementary school teaching experience.

532. RESEARCH PROBLEMS IN SECONDARY SCHOOL SOCIAL STUDIES (3) Rationale of the social studies curriculum for the middle and high school. Promising social studies programs for the adolescent. Prerequisites: a methods course in social studies and teaching experience.

533. RESEARCH IN THE TEACHING OF SOCIAL STUDIES (3) Procedures and methods of research for the teaching of social studies, strategies of investigation and review of research literature. Prerequisites: 12 credits in the social sciences on the 400 or 500 level and teaching experience.

DAIRY SCIENCE (D SC)

B. R. BAUMGARDT, *Head of the Department of Dairy and Animal Science*
324 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Almquist, Amann, Baumgardt, Flipse, Hargrove, Kesler, McCarthy, Muller, Patton, and Tanabe.

Graduate Faculty: Associate Members Buckalew, Shellenberger, Specht, and Thoele.

Students may specialize in dairy cattle nutrition, metabolism, dairy cattle genetics, dairy cattle management, and physiology of reproduction. A minor program generally is taken in agricultural economics, animal nutrition, biochemistry, genetics, physiology, or statistics. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language or communication skills.

Prerequisite to graduate work is the completion of an undergraduate major in animal industry, animal science, dairy science, or a related area. The undergraduate program must include mathematics and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

DAIRY SCIENCE (D SC)

- 405. DAIRY CATTLE MANAGEMENT (3) *Mr. Buckalew*
- 410. DAIRY HERD MANAGEMENT (4) *Mr. Muller*
- 423. ADVANCED DAIRY CATTLE JUDGING (1 per term, maximum of 2) *Mr. Buckalew*

DEVELOPMENTAL AND REMEDIAL READING

- 427. MILK SECRETION (3) *Mr. Kesler*
- 431. PHYSIOLOGY OF REPRODUCTION IN FARM ANIMALS (3) *Mr. Amann*
- 490. COLLOQUIUM (1)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 507. DAIRY CATTLE MANAGEMENT (1-6) *Mr. Buckalew and Staff*
- 511. DAIRY CATTLE NUTRITION (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr. 401. *Mr. Kesler*
- 512. ADVANCED STUDIES IN MILK SECRETION (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Mr. Kesler*
- 513. DAIRY CATTLE BREEDING (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: An.Sc. 322, Biol. 422, 3 credits in statistics. *Mr. Hargrove*
- 515. ADVANCED PHYSIOLOGY OF REPRODUCTION IN FARM ANIMALS (1-6) *Mr. Almquist*
- 516. ARTIFICIAL BREEDING OF FARM ANIMALS (1-6) Prerequisite: D.Sc. 431. *Mr. Almquist*
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

DEVELOPMENTAL AND REMEDIAL READING (D R R)

CAROL A. CARTWRIGHT, *In Charge of Graduate Program in Developmental and Remedial Reading*
155 Chambers Building

Degree Conferred: M.Ed.

Graduate Faculty: Senior Members Askov, Bliesmer, Cartwright, Golub, and Heilman.

Graduate Faculty: Associate Members M. Dupuis and Fairchild.

The purpose of the master's program is to prepare classroom teachers in elementary and secondary schools for more effective teaching of reading and to provide preparation for supervisory and administrative positions relative to reading in school systems.

Candidates for a master's degree must meet the requirements for admission to graduate study and, in addition, (1) must hold, or be eligible to hold, a valid teaching certificate (persons not meeting this criterion may work on overcoming deficiencies; graduate credit, but not degree credit, may be received for graduate courses taken to overcome such deficiencies) and (2) must have had at least one year of teaching experience or the equivalent.

The master's program has been planned so that those completing the program will also meet the state requirements for "reading specialist" certification.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Detailed descriptions of courses available in reading may be found under Reading, Communication, and Language Education: RCLEd.405, 420, 440, 446, 450, 526, 540, 545, 550, 551, 557, 596, 597.

EARTH SCIENCES (EARTH)

E. WILLARD MILLER, *Chairman of the Committee on Earth Sciences*
101 Mineral Sciences Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Blackadar, Cuffey, Dachille, de Pena, Dutton, Hosler, Lavin, Lewis, Miller, Panofsky, Thomson, Thornton, Traverse, Wernstedt, Williams, and Wright.

Graduate Faculty: Associate Members Cahir, Olivero, and J. Pena.

The M.Ed. program is designed to meet the needs of science teachers in elementary and secondary schools. The earth science fields of study are geography, geological sciences (geology, geochemistry and mineralogy, or geophysics), and meteorology. The student selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a paper in that area. An additional 12 credits must be taken in the other two fields of earth sciences; or 6 credits may be taken in one of the earth science fields plus 6 credits in other science or engineering fields. Two education courses, C.&S. 400 and Sci.Ed. 558, are required as a minor.

Students with a 2.50 junior-senior average, 18 credits in education and related psychology, and 6 credits in earth science fields or other appropriate background will be considered for admission to the M.Ed. program. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. The M.Ed. program is not offered during the summer term.

The D.Ed. program is designed for secondary school and college science teachers. The course requirements are planned by the candidate's committee. A minimum of 60 credits must include one area of concentration within the earth sciences — geography, geological sciences (geology, geochemistry and mineralogy, or geophysics), or meteorology — plus courses from each of the other two earth science areas. A minimum of 15 credits each is required in professional education and in thesis research. The thesis topic must be in one of the earth sciences. Three consecutive terms of residence are required for the D.Ed. degree. The student's D.Ed. committee shall normally consist of five members — two members from the area of concentration, one member from each of the other two earth science fields, and one member from education.

In order to enter the D.Ed. program a candidate should present evidence of competence at the baccalaureate level in one of the earth sciences (geography, geological sciences, or meteorology) or in an allied science curriculum. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.70 grade-point average will be made for students with special backgrounds, abilities, and interests.

EARTH SCIENCES (EARTH)

400. EARTH SCIENCES SEMINAR (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

500. EARTH SCIENCES RESEARCH (1-6) Relationships between the earth sciences revealed by theory, analytical methods, or a selected problem.

ECOLOGY (ECLGY)

FREDERICK M. WILLIAMS, *In Charge of Graduate Programs in Ecology*
327 Erwin W. Mueller Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baker, Bellis, Butler, Cooper, Cuffey, DeWalle, Dunson, George, Graves, Guber, Hower, Hutnik, Kim, Lindzey, MacCluer, Patil, Rothenbacher, Schein, Shipman, and F. Williams.

Graduate Faculty: Associate Members Arnold, Burris, Davis, Kurland, Pearson, and Reimer.

This intercollege program emphasizes the properties of ecosystems by focusing attention on interactions of single organisms, populations, and communities with their environment. It is designed to give students a basic understanding of ecological theory and is, therefore, complementary to other environmental programs which emphasize man's role in ecosystems.

The instructional program includes three graduate core courses in ecology, augmented by an additional integrated group of seminars and courses selected for each student by the committee, and a research project directed by the thesis adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. The nonthesis option is available for the M.S. degree.

The program is administered by a committee drawn from faculty members in several departments and colleges of the University. This committee and its chairman are appointed by the dean of the Graduate School. The instructional staff is composed of participating faculty in those departments offering graduate courses in fields closely allied to ecology.

The committee appointed by the Graduate School for each candidate in ecology is selected from members of the program committee and faculty from the student's area of specialization. The committee has the responsibility for determining the course program and research acceptable in satisfying degree requirements.

Students meeting the admission requirements of the Graduate School will be considered up to the number of spaces available in selecting candidates in this program. Candidates should have a strong science background including chemistry, physics, and mathematics. Preparation in biological sciences is also desirable. Students with a unique background in another discipline which has potential value to original ecological work will be seriously considered.

Students are strongly urged to choose their research interests and initiate communication with the relevant faculty member(s) before applying for admission. This is especially crucial if the student is seeking financial aid. Teaching and research assistantships are available only through the student's faculty adviser.

In addition to the formal application, the applicant should forward the following *directly to the program chairman*: (1) two or more letters of recommendation regarding the student's academic and professional promise; (2) a concise one-page statement describing the student's goals both within the program and in professional life; and (3) Graduate Record Examination scores including verbal, quantitative, and an advanced test. More specific inquiries may be directed to the program chairman.

Detailed descriptions of courses now available for students majoring in ecology may be found under the offerings of several departments: Anthy. 502, 523; Biol. 433, 434, 435, 436, 451, 480, 481, 516, 519, 544, 545, 546; C.E. 472, 579, 580; Cmp.Sc. 402; Ent. 416, 517, 535; E.R.M. 410, 413; For. 508, 517; Geol. 503; G.Sc. 425, 426, 547; Meteo. 505; Micrb. 400, 413, 529; Phil. 512; P.Path. 424; Stat. 524; V.Sc. 401; Wildl. 446, 551.

ECOLOGY (ECLGY)

590. COLLOQUIUM (1-3)

ECONOMICS (ECON)

GRANT N. FARR, *Head of the Department*
613 Kern Graduate Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Senior Members Budd, Farr, Feller, Herendeen, Hu, Klein, Nelson, Newman, Prybyla, Riew, Robinson, Rodgers, Rozen, and Smith.

Graduate Faculty: Associate Members Bergston, Coelen, Dickinson, Feinberg, Ferrar, Fox, Friedrich, Glyde, McIntyre, Mehra, Neumann, Rosenberg, Soladay, Stephenson, Wasylenko, Wentzler, and Witte.

Opportunities are available for concentration in the following fields: economic analysis, economic doctrines, economic development of developed areas, economic development of underdeveloped areas, economic fluctuations, income distribution, industrial organization, international economics, comparative economic systems, labor economics, money and banking, public finance, quantitative economics, statistics, and regional economics.

Students may also qualify for admission to the program in population issues, consisting of interdisciplinary course work with special emphasis on the economic, social, and geographic issues arising from the dynamics of population change.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by any of the following alternatives: (1) a reading knowledge of two foreign languages, (2) a reading knowledge of one foreign language and 6 credits of other course work from designated areas which increase research skills, (3) the equivalent of 12 credits of departmentally approved course work which increases research skills, or (4) a comprehensive knowledge of one foreign language. The nonthesis option is available for the M.A. degree; a student choosing the program option in operations research must complete a thesis.

To enter graduate work in economics a student should have completed at least 18 undergraduate credits in the fields of economics, accounting, commerce, and business statistics, including at least 6 credits in economics. All applicants must take the Graduate Record Examination in advanced economics and general aptitude.

Students with a 2.50 junior-senior average, a 3.00 average in courses in economics, and appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.A. degrees (see p. 238).

ECONOMICS (ECON)

- 400. HISTORY OF ECONOMIC THOUGHT I (3)
- 401. HISTORY OF ECONOMIC THOUGHT II (3)
- 404. CURRENT ECONOMIC ISSUES (3)
- 405. ADVANCED ECONOMIC ANALYSIS (3)
- 412. LABOR MARKETS AND COLLECTIVE BARGAINING (3)
- 413. (L.S. 413) COMPARATIVE LABOR MOVEMENTS (3)
- 414. (L.S. 414) THEORIES OF THE LABOR MOVEMENT (3)
- 415. ECONOMICS OF INCOME MAINTENANCE (3)
- 423. STATE AND LOCAL TAXATION (3)
- 424. URBAN ECONOMICS (3)
- 425. ECONOMICS OF PUBLIC EXPENDITURES (3)
- 427. (Ed.Adm. 427) ECONOMICS OF EDUCATION (3)
- 428. ENVIRONMENTAL ECONOMICS (3)
- 429. ADVANCED PUBLIC FINANCE (3)
- 433. INTERNATIONAL MONETARY ECONOMICS (3)
- 442. MONOPOLY, COMPETITION, AND THEIR REGULATION (3)

445. (H.P.A. 445) HEALTH ECONOMICS (3)
450. THE BUSINESS CYCLE (3)
451. MONETARY THEORY AND POLICY (3)
461. ECONOMIC GROWTH: UNDERDEVELOPED AREAS (3)
462. ECONOMIC GROWTH: THEORIES OF UNITED STATES DEVELOPMENT (3)
463. ECONOMIC DEMOGRAPHY (3)
480. MATHEMATICAL ECONOMICS (3)
489. HONORS THESIS (3)
490. INTRODUCTION TO ECONOMETRICS (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
499. FOREIGN STUDY IN ECONOMICS (2-6)

500. ECONOMIC SEMINAR (3-6)
502. MICROECONOMIC ANALYSIS (3) Economic behavior under pure and imperfect competition; price and output determination in product markets; prices and employment in factor markets.
503. MACROECONOMIC ANALYSIS (3) National income accounts; determination of income, employment, interest rates, and the price level; stabilization policy.
506. PROBLEMS IN ECONOMICS (1-12) Planned projects involving library, laboratory, or field work.
507. INTERNATIONAL TRADE (3) A survey of international trade theory including modern developments of pure theory, and of international trade policy.
508. CURRENT MONETARY THEORY AND POLICY (3) Post-Keynesian reformulation of quantity and Keynesian theories of money; liquidity and general equilibrium approaches; current issues in theory and policy.
510. ECONOMETRICS (3-6) Statistical estimation in mathematically formulated economic relationships.
513. DEVELOPMENT OF ECONOMIC DOCTRINES (3-6)
515. ECONOMICS OF THE LABOR MARKET (3) Theory and problems of labor-management relations; selected problems of the labor market with reference to current research and developments.
516. ECONOMICS OF HUMAN RESOURCES (3) Analysis of changes in human resource supply and demand; factors affecting these changes; current human resource policies.
517. INTERNATIONAL FINANCE (3) Problems of international liquidity; balance of payments adjustment; international financial institutions and selected policy problems.
518. DEVELOPMENT OF MONETARY THEORY (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.
519. (Mn.Ec. 519) MINERAL POLICY ANALYSIS (3) Principles of policy analysis; cost-benefit and other analytical techniques; environmental analyses; case studies of legislative and administrative mineral policy issues.
521. ADVANCED MICROECONOMIC THEORY (3-6) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.
522. ADVANCED MACROECONOMIC THEORY (3-6) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.
524. INCOME DISTRIBUTION (3) Measurement of inequality; ethical issues in income redistribution; measurement and determination of distributive shares; problem of poverty.
525. ECONOMICS OF TECHNOLOGICAL CHANGE (3) Theoretical and empirical analysis of invention and innovation and their effects on productivity, employment, and market structure.
529. PUBLIC FINANCE (3-6) Contemporary problems in public finance; instruments of fiscal policy in the achievement of full employment, price stability, and economic development.

530. REGIONAL MICROECONOMICS (3) Theoretical and empirical analysis of industrial location as determined by costs, markets, and agglomeration effects.
531. REGIONAL MACROECONOMICS (3) Aggregate regional trade flows; sources of regional economic data; techniques for measuring regional economic activity; long-run regional growth.
543. INDUSTRIAL ORGANIZATION AND PUBLIC POLICY (3) The structure of American industry; performance and behavior; public policies toward business.
550. ECONOMIC FLUCTUATIONS (3) Analysis of the various theories of economic fluctuations; their methodological premises.
551. STABILIZATION POLICY (3) Description and analysis of the alternatives and issues in stabilization policy.
560. SEMINAR IN ECONOMIC GROWTH: UNDERDEVELOPED AREAS (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.
561. SEMINAR IN ECONOMIC GROWTH: DEVELOPED AREAS (3-6) Growth models; strategic factors in growth; quantification problems; public policy.
571. COMPARATIVE ECONOMIC SYSTEMS (3-6) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision making and control.
572. SOVIET AND OTHER CENTRALLY PLANNED ECONOMIES (3-6) Principles, structure, and performance of centrally planned economies with special emphasis on the Soviet Union.
580. MATHEMATICAL ECONOMICS (3-9) Mathematical development of static and dynamic economic models: partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: Econ. 480.
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

G. P. CARTWRIGHT, *In Charge of Graduate Programs in Education of Exceptional Children*
307 CEDAR Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members C. Cartwright, G. Cartwright, French, Neisworth, Salvia, and Smith.

Graduate Faculty: Associate Members Axelrod, Gajar, Moore, Sindelar, and Ward.

Exceptional children are those who deviate so far from average in physical, intellectual, emotional, or social characteristics that they cannot profit adequately from the usual public school program. It is the purpose of this program to prepare teachers, researchers, administrators, and college and university teachers in the areas encompassing the education of the mentally retarded, gifted, emotionally disturbed, neurologically impaired, or learning disabled. A multidisciplinary approach is emphasized. The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages.

Prerequisites for a master's program include: 24 credits basic to the education of exceptional children (courses comparable to D.R.R. 441; E.E.C. 400, 401, 403, 454; E.E.C. 410 or 430 or 470; Mth.Ed. 420; a 400-level course in child development or child psychology; and a 400-level course in foundations of education).

Highest admission priorities are given to applicants who possess certification in special education or elementary education. Applicants for master's and doctoral programs must present evidence of superior academic achievement and aptitude, complete a personal statement, and provide professional references. Applicants for doctoral study must have had at least two years of relevant experience with handicapped children.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

400. INTRODUCTION TO EXCEPTIONAL CHILDREN (3)
 401. EDUCATIONAL ADJUSTMENTS FOR EXCEPTIONAL CHILDREN (3)
 403. CLINICAL TEACHING WITH EXCEPTIONAL CHILDREN (3)
 405. PRACTICUM IN THE EDUCATION OF EXCEPTIONAL CHILDREN (1-12)
 410. THE MENTALLY RETARDED (3)
 411. INSTRUCTION FOR THE SEVERELY MENTALLY RETARDED (2)
 412. INSTRUCTION FOR MILDLY HANDICAPPED CHILDREN (2)
 420. THE MENTALLY GIFTED (3)
 430. LEARNING DISABILITIES (3)
 440. (S.P.A. 440) SURVEY OF SPEECH AND HEARING DISORDERS (3)
 454. DIAGNOSIS OF EDUCATIONAL DISABILITIES (3)
 460. EDUCATION OF VISUALLY HANDICAPPED CHILDREN (1)
 470. THE EMOTIONALLY DISTURBED (3)
 472. EDUCATIONAL PROBLEMS OF ALIENATED YOUTH (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
500. SEMINAR IN SPECIAL EDUCATION (1-9) Continuing series of professional seminars designed to provide a forum for discussion of current and classical research concerning exceptional children. Prerequisites: Ed.Psy. 400 and 6 credits in education of exceptional children.
501. ADMINISTRATION AND SUPERVISION OF EDUCATIONAL PROGRAMS FOR EXCEPTIONAL CHILDREN (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisites: E.E.C. 401 and Ed.Adm. 480, or teaching or administrative or supervisory experience.
502. INTERNSHIP IN SPECIAL EDUCATION (2-10) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty. Prerequisite: E.E.C. 405 or teaching experience.
505. PRACTICUM (1-6) Supervised clinical experience on campus in University-managed diagnostic and remedial settings.
506. FIELD EXPERIENCES IN OFF-CAMPUS LABORATORIES (1-10) Supervised off-campus field experiences in selected laboratory settings with exceptional children. Prerequisite: E.E.C. 505.
507. INTERNSHIP IN SPECIAL EDUCATION SUPERVISION (1-6) Internship in day/residential school setting under supervision of field supervisor and University faculty. Prerequisite: E.E.C. 506.
509. PROBLEMS, PROJECTS, AND AREA STUDIES IN SPECIAL EDUCATION (1-9) May not be used for thesis credit. Prerequisite: 12 graduate credits in special education.
510. PROBLEMS IN THE EDUCATION OF THE MENTALLY RETARDED (2-4) Study of existing curriculums, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience and E.E.C. 410.
520. PROBLEMS IN THE EDUCATION OF THE MENTALLY GIFTED (2-4) Analysis of educational needs of the mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience and E.E.C. 420.
530. PROBLEMS IN THE EDUCATION OF THE LEARNING DISABLED (2-4) Review of the research and theoretical implications in the educational and behavioral management of learning disabled children. Prerequisite: E.E.C. 430.
545. (S.P.A. 545) CEREBRAL PALSY (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multiprofessional habilitative program. Prerequisite: S.P.A. 444.
547. (S.P.A. 547) LANGUAGE DISORDERS IN CHILDREN (2) Nature, etiology, diagnosis, and

management of language disorders in children. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.

554. **PSYCHOLOGICAL AND EDUCATIONAL EVALUATION OF EXCEPTIONAL CHILDREN (3)** Administration and interpretation of individual tests other than the Stanford-Binet, WISC, WAIS. Prerequisite: Psy. 559.

570. **PROBLEMS IN THE EDUCATION OF THE EMOTIONALLY DISTURBED (2-4)** Prerequisite: E.E.C. 470.

572. **SEMINAR IN THE EDUCATION OF ALIENATED GROUPS (2)** A study of the alienated and educational issues of coping with problems of social, cultural, and economic deprivation. Prerequisite: E.E.C. 472.

573. **PROBLEMS OF RESEARCH WITH ALIENATED GROUPS (2)** A seminar to review and design research studies for the education and training of alienated groups. Prerequisites: E.E.C. 472, 572.

596. **INDIVIDUAL STUDIES (1-6)**

602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

EDUCATIONAL ADMINISTRATION (EDADM)

PATRICK D. LYNCH, *In Charge of Graduate Programs in Educational Administration*
318 Rackley Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Caldwell, Johnson, Lutz, Lynch, and Willower.

Graduate Faculty: Associate Member Gipp.

Professional preparation programs are offered at the master's and doctoral degree levels for elementary and secondary school personnel whose objectives are to become prepared in education policy-making positions such as principals, supervisors, superintendents, intermediate unit officials, state and federal education agency personnel, professors of educational administration, or researchers in educational administration.

All candidates who seek M.Ed. and M.S. degrees in educational administration shall complete programs embracing a minimum of 30 graduate credits. Only in rare instances, however, to fulfill unusual objectives, will candidates be permitted to work toward the M.S. degree. In Pennsylvania a certification program consisting of at least 45 credits is required before one can become a public school administrator. Courses may be taken at the Capitol Campus; however, admission to the M.Ed. program must be approved by the University Park program chairman.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign and native American languages.

Candidates for the D.Ed. and Ph.D. degrees are required to complete a minimum of three consecutive terms during a calendar year in residence.

From the time of initiation of a 600-level thesis research program, all doctoral candidates shall continuously register (at least three terms per calendar year) until the termination of the graduate program. Failure to register for doctoral thesis credits in three out of four terms shall be considered automatic withdrawal. Specific requirements with respect to the Ph.D. and D.Ed. degrees may be learned from a departmental bulletin that is available upon request and from additional information on pages 71-73 of this catalog. Although candidates are required to specialize in a field of educational administration, they are encouraged to acquire a background in the social sciences and the humanistic foundations.

Requirements for admission to a graduate program in educational administration ordinarily include 18 approved undergraduate credits in education and psychology. All applicants for any graduate

program, including certification, must submit either a Miller Analogies Test or Graduate Record Examination (quantitative and verbal) score. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Students with a 2.60 junior-senior average and with appropriate course backgrounds will be considered for admission to a master's program. Exceptions to the minimum 2.60 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

EDUCATIONAL ADMINISTRATION (EDADM)

- 427. (Econ. 427) ECONOMICS OF EDUCATION (3)
- 460. (Hi.Ed. 460) INTRODUCTION TO ADULT EDUCATION (3)
- 480. EDUCATIONAL ADMINISTRATION (2-3)
- 481. COLLECTIVE NEGOTIATIONS IN PUBLIC EDUCATION (3)

- 525. FEDERAL EDUCATION POLICIES (3) Analysis of federal role in development of educational policy and its relationship to state and local policy.
- 528. POLITICS AND EDUCATION (3) Social forces which shape the educational system and determine national, state, and local educational policies.
- 533. THE POLITICS OF LOCAL SCHOOL DISTRICTS (3) The methodology of studying political decision making and the theory and practice of politics in local school districts. Prerequisite: 6 credits of sociology, anthropology, or political science.
- 560. SYSTEM THEORY IN EDUCATION (3) Concepts of general system theory, the systems approach, and related methodologies and tools; applications in education; critique of instructional systems. Prerequisites: Ed.Psy. 400, 475.
- 565. PERSONNEL AND GRIEVANCE ADMINISTRATION (2-3) Practice and theory of personnel supervision at the central office and building level, including contract administration and grievance handling. Prerequisites: 18 credits in education and three years' teaching experience.
- 567. ORGANIZATIONAL SUPERVISION (3) The organizational context of the school, its relationship to supervision, and the improvement of instruction. Prerequisites: Ed.Adm. 480 and teaching experience.
- 568. THE PRINCIPALSHIP (2-3) For elementary and secondary principals. The administrative and management tasks of building administration. The social system, change, and community relationships.
- 569. PRINCIPALSHIP SEMINAR (2-3) The study and application of interdisciplinary-based products and processes in the various organizational units within the educational system.
- 571. THE EDUCATIONAL PLANT (2-3) School plant needs in terms of school population and curriculums; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventilation, equipment, school building costs and finance. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
- 572. ANALYSIS OF SCHOOL-COMMUNITY RELATIONS (2-3) School-community relationships; social structure, social change, and the schools; case studies of community-school problems. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
- 573. PUBLIC SCHOOL FINANCE (2-3) Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money management. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
- 574. THEORY AND PRACTICE OF EDUCATIONAL NEGOTIATIONS (2-3) Theoretical framework, bargaining strategies, legislation, administrative roles, agreements, etc. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience, and previous work in school administration.

575. (Hi Ed. 575) **ADMINISTRATION OF ADULT EDUCATION (3)** The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
576. **LEGAL ASPECTS OF SCHOOL ADMINISTRATION (3)** Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies, the course of study, textbooks; contracts; taxes, torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
577. **ECONOMIC DIMENSIONS OF EDUCATIONAL ADMINISTRATION (3)** Application of selected economic concepts and tools of analysis to administrative decision and planning processes in educational systems. Prerequisite: Ed.Adm. 480.
578. **DYNAMIC FACTORS IN SCHOOL ADMINISTRATION (2-3)** Intraorganizational relationships; administration and the school as a social system; formal and informal organization. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
579. **PUBLIC SCHOOL BUSINESS ADMINISTRATION (2-3)** Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience; Ed.Adm. 573.
580. **THE USE OF THEORY IN EDUCATIONAL ADMINISTRATION (1-6)** Administrative theories applied to educational organizations. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.
581. **FIELD RESEARCH IN EDUCATIONAL ADMINISTRATION (2-3)** Methods for appraisal of an educational program; planning for expansion, consolidation, or reduction of educational offerings. Prerequisite: Ed.Adm. 480, 6 credits in educational administration.
582. **INTERNSHIP IN ADMINISTRATION AND SUPERVISION (1-12)** Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.
583. **SUBSTANTIVE ISSUES IN SCHOOL LAW (3)** Focuses on substantive law in such areas as academic freedom, student records, teacher rights and responsibilities, and desegregation. Prerequisite: Ed.Adm. 576.
588. **WORKSHOP IN CURRENT EDUCATIONAL PROBLEMS (1-6)** For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.
589. **PROBLEMS, PROJECTS, AND AREA STUDIES IN EDUCATIONAL ADMINISTRATION (1-6)** Independent work in the study of topics in educational administration, or development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.
591. **SEMINAR IN PUBLIC SCHOOL RESEARCH (1-4)** Doctoral candidates present outlines of their theses to the graduate faculty of the department and advanced graduate students.
596. **INDIVIDUAL STUDIES (1-6)**

EDUCATIONAL PSYCHOLOGY (EDPSY)

JOSEPH FRENCH, *In Charge of Graduate Programs in Educational Psychology*
403 Carpenter Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members DiVesta, French, Games, Mitzel, Rabinowitz, Roberts, Seibel, Thevaos, Tjosvold, Weener, and Withall.

Graduate Faculty: Associate Members Barnette, Schwartz, and Snyder.

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in school learning, educational and psychological measurement, statistics and research design as applied to education, and the evaluation of educational programs. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, school psychology, and special education, are offered in other departments of the University.

Doctoral degree requirements include a major emphasis in one of the above areas of educational psychology with minor emphasis in one other related area. Typically, the doctoral program of study would include a minimum of one course in each of the following areas: research methods, educational and/or philosophical foundations, computer science, human learning, measurement, social or industrial psychology, experimental psychology, and developmental psychology. In lieu of the foreign language requirement for the Ph.D. degree, students are expected to present to the committee a statement of objectives and goals and a plan of the academic and nonacademic work to be undertaken in achieving these goals. Within the context of the above, the students are expected to incorporate relevant experiences which are now part of the language and communication requirements, whether in course work, research, or teaching, to increase their effectiveness as educational psychologists.

Special facilities available to the department include a research design laboratory, rooms for conducting research projects, facilities for film production and editing, and a closed-circuit television studio used for both research and instruction. Other facilities available to students majoring in educational psychology are the Nursery School, the Psychology Clinic, the Reading Center, the Center for Educational Diagnosis and Remediation, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with several computer systems, is available for use in graduate student research.

Students with a 3.00 junior-senior average and a broad undergraduate background including some college mathematics will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants are required to submit scores on the Graduate Record Examination. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one-half of their graduate credits of A quality.

EDUCATIONAL PSYCHOLOGY (EDPSY)

- 400. INTRODUCTION TO STATISTICS IN EDUCATIONAL RESEARCH (3)
- 406. APPLIED STATISTICAL INFERENCE FOR THE BEHAVIORAL SCIENCES (3)
- 421. LEARNING PROCESSES IN RELATION TO EDUCATIONAL PRACTICES (3)
- 450. (Psy. 450) PRINCIPLES OF MEASUREMENT (3)
- 451. APPRAISAL AND INTERPRETATION OF STANDARDIZED GROUP TESTS (2)
- 475. INTRODUCTION TO EDUCATIONAL RESEARCH (2)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501. CURRENT TOPICS IN EDUCATIONAL PSYCHOLOGY (2-6) Study of the current literature in educational psychology with emphasis on historical and theoretical aspects of important areas of investigation. Prerequisites: Ed.Psy. 406, 421, and 450.

506. ADVANCED TECHNIQUES FOR ANALYZING EDUCATIONAL EXPERIMENTS (3) Analytical and

experimental control considerations for designs involving nested and/or crossed subjects. Analysis of variance and multiple comparisons via computers. Prerequisite: Ed.Psy. 406 or Psy. 415.

507. **MULTIVARIATE PROCEDURES IN EDUCATIONAL RESEARCH (3)** Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisite: Ed.Psy. 406 or Psy. 415.

512. **GROUP PROCESSES IN THE CLASSROOM (2)** Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.

513. **INDIVIDUAL AND GROUP DIFFERENCES (2)** Historical and contemporary attempts to relate individual differences to important social and educational issues. Prerequisite: Ed.Psy. 400 or Psy. 15.

518. **CONTEMPORARY LEARNING MODELS IN EDUCATIONAL PSYCHOLOGY (3)** Contemporary mathematical models and computer simulations of complex human learning occurring in school settings. Modes for analyzing the learning environment. Prerequisite: Ed.Psy. 421.

519. **PSYCHOLOGICAL FOUNDATIONS FOR COLLEGE TEACHING (2)** Psychological, sociological and organizational variables which influence college student behavior. Designed for graduate students who anticipate careers in college teaching.

522. **CONCEPT LEARNING IN THE SCHOOLS (2)** Study of theory and research related to concept formation and attainment with implications for instruction. Prerequisite: Ed.Psy. 421.

523. **PROBLEM SOLVING IN THE SCHOOLS (2)** Examination of theory and research related to cognitive processes in problem solving with implications for educational practice. Prerequisite: Ed.Psy. 421.

524. **THEORIES OF LEARNING AND INSTRUCTION (3)** Study of major classical theories of learning and recent developments in learning and instructional theory. Prerequisite: Ed.Psy. 421.

526. **(RCLEd.526) THE PSYCHOLOGY OF READING (3)** Psychological principles underlying the process of reading and comprehending with application to instruction. Prerequisite: Ed. Psy. 421.

550. **DESIGN AND CONSTRUCTION OF PSYCHOLOGICAL MEASURES (3)** Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive validity. Prerequisite: Ed.Psy. 450.

554. **THEORIES OF PSYCHOLOGICAL MEASUREMENT (2)** Basic true-score and error models; their extensions to test reliability and test validity; problems of item analysis and weighting. Prerequisite: Ed.Psy. 450.

575. **SEMINAR IN EDUCATIONAL PSYCHOLOGY (3-9)** A seminar dealing with specific topics in educational psychology. Open to advanced students in the behavioral sciences.

591. **PROBLEMS AND PROJECTS IN EDUCATIONAL PSYCHOLOGY (1-6)** Independent work on special topics.

ELECTRICAL ENGINEERING (E E)

WILLIAM J. ROSS, *Head of the Department*
118 Electrical Engineering East

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Adams, Bredeson, Brown, Cross, Das, Etzweiler, Ferraro, Geselowitz, Hale, Lachs, Lee, Lewis, McMurtry, Nisbet, Ross, and Young.

Graduate Faculty: Associate Members Carpenter, Delansky, Hulina, Mathews, Robinson, Stach, Stein, Symons, Trutt, and Voltmer.

The principal areas of graduate research are in ionospheric studies, solid state electronics, computers and digital systems, and power systems. Course offerings support these research areas as well as work

in automatic control, biomedical engineering, communications, electromagnetics, network and system theory, plasmas, and quantum electronics.

The requirements for the M.S. degree may be satisfied through (1) a thesis option where the program includes a minimum of 24 course credits plus 6 thesis credits and the submission of an approved thesis, or (2) a nonthesis option where 30 course credits are required, together with the preparation of a scholarly report and the passing of an M.S. examination. No foreign language is required.

The communication and foreign language requirement for the Ph.D. degree does not specify a foreign language, but the candidate is required to demonstrate both written and oral proficiency in English.

To be admitted to the M.S. program without undergraduate deficiencies, a B.S. degree in electrical engineering from an accredited program, or its equivalent, is required with appropriate courses in electrical circuits, fields, and electronics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

ELECTRICAL ENGINEERING (E E)

- 405. ELECTRONIC INSTRUMENTATION FOR NONELECTRICAL ENGINEERS AND SCIENTISTS (3)
- 406. ELECTRICAL POWER GENERATION AND TRANSMISSION (3)
- 411. PRINCIPLES OF ELECTROMAGNETIC FIELDS (3)
- 413. LINEAR NETWORK ANALYSIS (3)
- 414. PRINCIPLES AND APPLICATIONS OF LASERS AND MASERS (3)
- 417. SYSTEM THEORY (3)
- 418. SOLID STATE DEVICE TECHNOLOGY (3)
- 419. SOLID STATE DEVICES (3)
- 423. FUNDAMENTALS OF INDUSTRIAL ELECTRONICS (3)
- 424. FUNDAMENTALS OF ELECTRICAL DESIGN (3)
- 425. SYMMETRICAL COMPONENTS (3)
- 428. LINEAR CONTROL SYSTEMS (3)
- 432. UHF AND MICROWAVE ENGINEERING (3)
- 438. ANTENNA ENGINEERING (3)
- 441. ACTIVE CIRCUITS (3)
- 448. LINEAR ELECTRONIC DESIGN (3)
- 449. DIGITAL ELECTRONIC DESIGN (3)
- 450. NETWORK ANALYSIS (3)
- 458. DATA COMMUNICATION (3)
- 459. INTRODUCTION TO STATISTICAL THEORY OF COMMUNICATIONS (3)
- 461. FUNDAMENTALS OF POWER SYSTEM STABILITY (3)
- 470. ELECTRONIC ANALOG COMPUTERS (3)
- 471. LOGICAL DESIGN OF SWITCHING SYSTEMS (3)
- 472. INTRODUCTION TO DIGITAL SUBSYSTEMS (3)
- 475. INTRODUCTION TO HYBRID COMPUTATION (3)
- 477. SYNTHESIS AND DESIGN OF ELECTRICAL SYSTEMS (3)
- 490. (Nuc.E. 490) INTRODUCTION TO PLASMAS (3)
- 492. (Astro. 492) SPACE ASTRONOMY AND INTRODUCTION TO SPACE SCIENCE (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

519. SEMICONDUCTOR DEVICES (3) Characteristics and limitations of bipolar transistors, diodes, transit time and bulk-effect devices. Prerequisite: E.E. 419.

521. ADVANCED ELECTRICAL ENGINEERING PROBLEMS (1-10)

523. NONLINEAR ANALYSIS (3) Transient and steady state analysis of nonlinear physical systems; phase plane analysis, iterative techniques, singular points, and subharmonics. Prerequisite: E.E. 435.

527. **LINEAR CONTROL SYSTEMS (3)** Continuous and discrete-time linear control systems; state variable models; analytical design for deterministic and random inputs; time-varying systems stability. Prerequisites: E.E. 428 or M.E. 455; E.E. 417.
528. **NONLINEAR CONTROL AND STABILITY (3)** Design of nonlinear automatic control systems; phase-plane methods; describing functions; optimum switched systems; Liapunov stability; special topics in stability. Prerequisites: E.E. 428 or M.E. 455; E.E. 417.
529. **OPTIMAL CONTROL (3)** Variational methods in control system design; classical calculus of variations, dynamic programming, maximum principle; optimal digital control systems; state estimation. Prerequisite: E.E. 527.
530. **ADAPTIVE AND LEARNING SYSTEMS (3)** Adaptive and learning control systems; system identification; performance indices; gradient, stochastic approximation, controlled random search methods; introduction to pattern recognition. Prerequisite: E.E. 527.
535. **ENGINEERING ANALYSIS (3)** Applications of mapping methods, series and integral representations to the solution of boundary value problems in electrical engineering. Prerequisite: E.E. 437.
540. (Nuc.E. 540) **THEORY OF PLASMA WAVES (3)** Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: E.E. 490.
541. (Nuc.E. 541) **PLASMA THEORY (3)** Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: E.E. 540 (Nuc.E. 540).
546. **FIELD-EFFECT DEVICES (3)** The physical background, characteristics and limitations of surface field-effect and junction field-effect devices and related structures. Prerequisite: E.E. 419.
547. **DIELECTRIC DEVICES (3)** Applications of insulator physics and devices based on insulator properties. Prerequisite: E.E. 419.
548. **LINEAR INTEGRATED CIRCUITS (3)** Design of monolithic, thin-film and hybrid linear integrated circuits; D.C., video, tuned, r.f. and microwave applications. Emphasis on reliability. Prerequisites: E.E. 418, 448.
550. **NETWORK SYNTHESIS (3)** Positive real functions, realizability conditions, synthesis of driving point immittances, synthesis of two-terminal pair networks, transfer function synthesis. Prerequisites: E.E. 437, 450.
560. **STATISTICAL THEORY OF COMMUNICATIONS (3)** Generalized harmonic analysis; the application of correlation and convolution to the detection of signals in noise; various special topics. Prerequisite: E.E. 459 or Math. 409.
561. **INFORMATION THEORY (3)** Mathematical measurement of information; information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems. Prerequisite: E.E. 459 or Math. 409.
562. **DETECTION THEORY (3)** Detection decision theory, Bayes and Neyman-Pearson criteria, optimal receivers, classical estimation theory, signal-noise representations, optimum linear signal parameters estimation. Prerequisite: E.E. 560.
566. **ALGEBRAIC CODING THEORY (3)** Polynomial rings, galois fields, linear codes, cyclic codes, BCH codes, finite projective geometry cyclic codes, convolution codes, graph theoretic codes. Prerequisite: Cmp.Sc. 450 or E.E. 561.
569. **SIMULATION OF BIOMEDICAL SYSTEMS (3)** Simulation of biological and medical systems on analog and digital computers; direct electrical analogs; modeling techniques. Prerequisites: E.E. 470 or Cmp.Sc. 401; Biol. 11.
570. **ADVANCED ELECTRONIC ANALOG COMPUTERS (3)** Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.
571. **DIGITAL COMPUTERS: RECENT DEVELOPMENTS AND ADVANCED LOGIC (3)** Advanced treatment of logical design; discussion of topics of current interest in the general area of digital computers. Prerequisite: E.E. 471.

572. **DIGITAL SYSTEM DESIGN (3)** Complete digital system design including specification, internal organization, and realization. Discussion of interaction among digital systems and subsystems. Prerequisite: E.E. 472.

573. **FAULT DETECTION IN DIGITAL CIRCUITS (3)** Advanced treatment of fault detection, location and redundancy techniques. Prerequisite: E.E. 471.

580. **RADIO WAVES AND THE IONOSPHERE (3)** The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 62 or 438 or Phys. 557.

581. **CONSTITUTION OF THE IONOSPHERE (3)** Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

ENGINEERING MECHANICS (E MCH)

JOHN R. MENTZER, *Head of the Department of Engineering Science and Mechanics*
227B Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Conway, Davids, Fonash, Hayek, Haythornthwaite, Hu, Kiusalaas, Mentzer, Neubert, Sharma, Thompson, and Zamrik.

Graduate Faculty: Associate Members Cook, Kimmel, Llorens, MacDonald, Pytel, and Queeney.

Graduate programs in engineering mechanics emphasize fundamental knowledge and include research opportunities in theoretical and experimental mechanics, with a primary focus on the mechanics and physics of solids.

Graduate study is available in continuum mechanics, structural mechanics, dynamics, vibrations and acoustics, biomechanics, micromechanics, experimental mechanics, and properties of materials. Thesis work in these areas is frequently directed toward specific applications of technological interest in biosystems, geosystems, energy production and distribution, materials engineering, and structural design.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Programs leading to a minor in engineering mechanics are available for doctoral students who seek to complement their studies in their major fields by acquiring a broader background in theoretical and experimental mechanics.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Other course offerings of the department are listed under *Other Graduate Courses*.

ENGINEERING MECHANICS (E MCH)

- 400. **ADVANCED STRENGTH OF MATERIALS AND DESIGN (3)** *Mr. Hu*
- 401. **DESIGN AND SYNTHESIS IN VIBRATIONS (3)** *Mr. Hayek*
- 402. **APPLIED AND EXPERIMENTAL STRESS ANALYSIS (3)** *Mr. Conway*
- 403. **STRENGTH DESIGN IN MATERIALS AND STRUCTURES (4)** *Mr. Queeney*
- 407. **COMPUTER METHODS IN ENGINEERING DESIGN (3)** *Mr. Kiusalaas*
- 408. **ELASTICITY AND ENGINEERING APPLICATIONS (3)** *Mr. Kiusalaas*
- 409. **ADVANCED MECHANICS (3)** *Mr. Pytel*
- 410. **MECHANICS OF SPACE FLIGHT (3)** *Mr. Pytel*

412. EXPERIMENTAL METHODS IN VIBRATIONS (3) *Mr. Neubert*
413. PLASTIC ANALYSIS OF STRUCTURES (3) *Mr. Haythornthwaite*
414. ELEMENTS OF MATERIAL SCIENCE (3) *Mr. Kimmel*
415. FRACTURE MECHANICS (3) *Mr. Queeney*
421. CONTINUUM MECHANICS (3) *Messrs. Hu and Pytel*
422. CONTINUUM MECHANICS (3) *Mr. Hu*
446. MECHANICS OF VISCOELASTIC MATERIALS (3) *Mr. Sharma*
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. ADVANCED MECHANICS OF MATERIALS (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-walled cylinders, shrink-fit assemblies, and rotating discs; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13. *Mr. Zamrik*
506. EXPERIMENTAL STRESS ANALYSIS (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507. *Mr. Conway*
507. THEORY OF ELASTICITY AND APPLICATIONS (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*
509. THEORY OF PLATES AND SHELLS (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*
514. ENGINEERING MECHANICS SEMINAR (1 per term) Current literature and special problems in engineering mechanics.
516. MATHEMATICAL THEORY OF ELASTICITY (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potential; applications. Prerequisite: E.Mch. 540. *Mr. Hayek*
520. ADVANCED DYNAMICS (3) Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12; Math. 72 or 431. *Mr. Pytel*
521. STRESS WAVES IN SOLIDS (3) Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact and numerical methods. Prerequisites: E.Mch. 12; Math. 405 or E.Mch. 524. *Mr. Davids*
522. THEORY OF VIBRATIONS (3) Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E.Mch. 13; Math. 72 or 431. *Mr. Neubert*
523. COMPUTER METHODS IN ENGINEERING ANALYSIS (3) Finite elements, finite differences, and matrix methods applied to dynamics, elasticity, wave propagation, heat conduction structural analysis, and fluid flow. Prerequisites: Cmp.Sc. 401, Math. 72. *Mr. Davids*
524. MATHEMATICAL METHODS IN ENGINEERING (3 per unit) *Messrs. Hayek and Thompson*
- Unit A* (3) Basic tools, including Fourier, Legendre, and other orthogonal series, special functions, Laplace transforms. Applications in mechanics and other fields. Prerequisite: Math. 102.
- Unit B* (3) Solution techniques for boundary-value problems in curvilinear coordinates, integral transforms. Green's functions, potentials, applications to diffusion, vibration, wave-propagation. Prerequisite: E.Mch. 524A or Math. 431.
525. VIBRATION AND SHOCK IN DAMPED MECHANICAL SYSTEMS (3) Rubberlike materials; vibration isolation; structural impedance; wave propagation; multforce excitation of beams; Timoshenko beams; transients; shock spectra; damage; nonlinear response. Prerequisite: E.Mch. 401 or 522. *Mr. Snowdon*

526. **NONLINEAR MECHANICS (3)** Integral curves, singular points, self-sustained oscillations, stability problems, Hill's and Van der Pol's equation, mechanical and electrical application. Prerequisite: E.Mch. 522. *Mr. Neubert*
527. **STRUCTURAL DYNAMICS (3)** Dynamic behavior of structural systems; normal modes; input spectra; finite element representation of frameworks, plates, and shells; impedance; elastic-plastic response. Prerequisites: E.Mch. 12, 13. *Mr. Neubert*
528. **EXPERIMENTAL METHODS IN VIBRATIONS (3)** Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, nondestructive testing. Prerequisite: E.Mch. 401 or 522. *Mr. Neubert*
530. **SOLID STATE MECHANICS (3)** Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. Prerequisite: E.Mch. 14. *Mr. Hu*
531. **THEORY OF PLASTICITY AND APPLICATIONS (3)** Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 507. *Mr. Hu*
533. **DETERMINATION OF MECHANICAL PROPERTIES (3)** Experimental methods for determining hardness, elastic constants, creep behavior, fatigue strength, plastic flow, and dynamic properties of metals. Prerequisite: E.Mch. 14 or 530. *Mr. Zamrik*
534. **PHOTOELASTICITY (3)** Analysis of polariscopes; isoclinics, isochromatics, and stress trajectories; two- and three-dimensional photoelastic methods; determination of principal stresses; model preparation. Prerequisite: E.Mch. 408 or 507. *Mr. Conway*
535. **(Metal. 535) CRYSTAL DEFECTS AND MECHANICAL RESPONSE (3)** Mechanical responses of crystalline solids containing point, line, and interfacial defects; elastic and plastic responses. Prerequisite: Metal. 514 or E.Mch. 414. *Mr. Queeney*
540. **INTRODUCTION TO CONTINUUM MECHANICS (3)** Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics. *Mr. Hayek*
546. **THEORY OF VISCOELASTICITY AND APPLICATIONS (3)** Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E.Mch. 507. *Mr. Sharma*
550. **STUDIES IN ENGINEERING MECHANICS (1-6)** Studies in any field of engineering mechanics.
570. **RANDOM VIBRATIONS IN STRUCTURAL MECHANICS (3)** Probability theory applied to random vibrations of linear and nonlinear systems; excitation by ground motion, turbulence, and noise; acoustic damping. Prerequisite: Aersp. 411 or E.Mch. 401 or 522. *Mr. Neubert*
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

ENGINEERING SCIENCE (E SC)

JOHN R. MENTZER, *Head of the Department of Engineering Science and Mechanics*
227B Hammond Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members Conway, Davids, Fonash, Hayek, Haythornthwaite, Hu, Kiusalaas, Mentzer, Neubert, Queeney, Sharma, Thompson, and Zamrik.

Graduate Faculty: Associate Members Cook, Kimmel, Llorens, MacDonald, and Pytel.

This program is characterized by strong components in engineering analysis, the basic sciences, and areas of emerging technological importance. The program is interdisciplinary in structure with

sufficient flexibility to allow a student to specialize in any of a variety of disciplines according to his or her professional objectives. The basic requirements of course work by subject area are as follows:

Engineering Analysis	— six credits
Materials	— six credits
Basic Sciences	— six credits
Engineering Sciences	— six credits

Within these guidelines, work in the listed areas may be arranged in consultation with the adviser to constitute a program of study to accommodate the objectives of the student, and it is expected that courses outside the department may constitute part of the content in the engineering sciences.

A thesis is required for the M.S. degree as part of the 30 credits required in the program.

Admission to the program requires a bachelor's degree in engineering or science from an accredited institution, with a junior-senior grade point average of at least 2.50. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

This program should be distinguished from the graduate program in engineering science at Behrend, Capitol, and King of Prussia which offers the M.Eng. degree.

ENGINEERING SCIENCE (E SC)

- 400. ELECTROMAGNETIC FIELDS (3)
- 401. SENIOR DESIGN PROJECT (2)
- 402. SENIOR DESIGN PROJECT (2)
- 403. SENIOR DESIGN PROJECT (3)
- 404. ANALYSIS IN ENGINEERING SCIENCE (3)
- 405. ENGINEERING APPLICATIONS OF FIELD THEORY (3)

501. SOLID STATE ENERGY CONVERSION (3) Principles of solid state energy conversion and their utilization in engineering devices. Emphasis on current research and development efforts. Prerequisite: E.E. 419 or Phys. 412.

NOTE: Other departmental courses are listed under *Engineering Mechanics*.

ENGINEERING SCIENCE (E SC)

ROBERT M. BARNOFF, *Chairman of the Engineering Graduate Committee for Off-Campus Programs*
220 Sackett Building

Degree Conferred: M.Eng.

Behrend College — Richard C. Bollinger, *Director of Program*

Graduate Faculty: Associate Members Bollinger and Salvia.

King of Prussia Graduate Center — Helmut E. Weber, *Director of Program*

Graduate Faculty: Senior Member Weber.

Graduate Faculty: Associate Members Callahan, Duncan, Kozik, Llorens, and Stein.

Capitol Campus — Robert A. Conover, *Director of Program*

Graduate Faculty: Senior Members Bissinger and Grenier.

Graduate Faculty: Associate Members Cole, Conover, Dahir, Ezard, Hartzler, Hary, Maynard, Miller, Murty, Rao, Shoup, Wade, and Welsh.

A program leading to the degree of Master of Engineering with a major in engineering science is offered at Behrend College, the King of Prussia Graduate Center, and at the Capitol Campus, near Harrisburg. Details of the program may be obtained by writing directly to these locations. Addresses are given in the front of this catalog.

The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of the student's major interest. It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area. Courses offered for the program are all established and controlled by the resident departments at the University Park Campus.

This program should be distinguished from the graduate program in engineering science at University Park which offers the M.S. degree.

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering which have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 30 credits is required, of which at least 12 must be at the 500 level. A scholarly written report is also required. Three of the above credits may be applied to this report.

Students may be admitted to the program from a wide variety of disciplines. Students applying for admission are expected to have completed the following core of courses: (1) physics through modern physics, (2) mathematics through differential equations, (3) one course in engineering thermodynamics, (4) one course in electrical circuits, and (5) basic courses in engineering statics and dynamics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details regarding admission requirements are available from the directors of the graduate centers offering the program.

ENGLISH (ENGL)

ROBERT W. FRANK, JR., *Head of the Department*
117 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Austin, Begnal, Condee, Crane, Frank, Hudspeth, R. Hume, Lewis, Lougy, Meserole, O'Donnell, Price, Walden, Weintraub, West, and Young.

Graduate Faculty: Associate Members Arnold, Balaban, Borklund, Buck, Buckalew, Burns, Damerst, Ebbitt, Eckhardt, Fitzgerald, Gidez, Grecco, K. Hume, Joukovsky, Kiernan, Mann, McAdams, Moore, Park, Rambeau, Rodgers, Rogers, Schneeman, Secor, Smith, Thigpen, Toth, and Trautman.

A student may specialize in English literature, American literature, or philology. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If the student does not present 18 credits in English, deficiencies must be made up early in the graduate program. For the M.A. in English, a minimum of 33 graduate credits is required. A thesis is required of all M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be met by successful performance in any one of the following options: (1) critical and scholarly competence in one area of the literature of a foreign language; (2) reading, writing, and speaking knowledge of one foreign language; (3) reading knowledge of two foreign languages; or (4) reading knowledge of one foreign language and demonstrated competence (normally by successful course work) in a technique such as computer science, statistics, etc., where relevant to the student's research interest.

Students with a 3.30 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.30 grade-point average may be made for students with special backgrounds, abilities, and interests. Graduate Record Examination scores are required.

ENGLISH (ENGL)

406. HISTORY OF THE ENGLISH LANGUAGE (3)
 407. HISTORY OF THE ENGLISH LANGUAGE FOR TEACHERS (3)
 408. APPLIED ENGLISH LANGUAGE ANALYSIS (3)
 410. RHETORICAL THEORY AND PRACTICE (3)
 411. PROBLEMS OF STYLE (3)
 412. THE WRITING OF FICTION (3-6)
 413. VERSE WRITING (3-6)
 414. BIOGRAPHICAL WRITING (3)
 415. NONFICTION WRITING (3 per term, maximum of 6)
 416. (Journ. 416) SCIENCE WRITING (3-6)
 418. ADVANCED TECHNICAL WRITING AND EDITING (3-6)
 430. MASTERS OF AMERICAN LITERATURE (3-6)
 431. MOVEMENTS IN AMERICAN LITERATURE (3-6)
 432. THE AMERICAN NOVEL TO 1900 (3)
 433. THE AMERICAN NOVEL SINCE 1900 (3)
 435. THE AMERICAN SHORT STORY (3)
 437. AMERICAN POETRY (3)
 438. AMERICAN DRAMA (3)
 439. AMERICAN NONFICTION PROSE (3)
 440. STUDIES IN BRITISH LITERATURE (3-6)
 441. CHAUCER (3)
 443. THE ENGLISH RENAISSANCE (3)
 444. SHAKESPEARE: THE GENRES (3)
 445. SHAKESPEARE'S CONTEMPORARIES (3)
 446. MILTON (3)
 451. THE RESTORATION AND THE EIGHTEENTH CENTURY (3)
 455. THE NOVEL IN ENGLAND TO JANE AUSTEN (3)
 460. THE ROMANTICS (3)
 464. THE VICTORIANS (3)
 465. VICTORIAN NOVEL (3)
 470. LITERATURE OF THE BRITISH COMMONWEALTH (3)
 475. MODERN BRITISH FICTION (3)
 477. MODERN POETRY (3)
 478. BRITISH AND IRISH DRAMA SINCE 1890 (3)
 484. (L.A. 484) COMPUTATIONAL AND QUANTITATIVE STYLISTICS (3)
 488. (C.Lit. 488) MODERN CONTINENTAL DRAMA (3)
 491. LITERATURE FOR TEACHERS IN SECONDARY SCHOOLS (3)
 492. HISTORY OF ENGLISH LITERARY CRITICISM (3)
 495. THE FOLKTALE IN AMERICAN LITERATURE (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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501. MATERIALS AND METHODS OF RESEARCH (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major.
 506. THE ENGLISH LANGUAGE (3) A problem-centered approach to literary and oral forms of English, utilizing historical and analytic perspectives.
 512. THE WRITING OF FICTION (3-6) Supervised workshop in advanced techniques of writing fiction.
 520. THE MIDDLE ENGLISH ROMANCE (3) A detailed study of the Middle English metrical romance in terms of its milieu and its genre in the West.
 521. OLD ENGLISH LANGUAGE (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry.

522. BEOWULF (3) Reading and critical analysis. Prerequisite: Engl. 521.
523. WORDSWORTH AND COLERIDGE (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period.
524. BYRON AND SHELLEY (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period.
525. BLAKE AND KEATS (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period.
526. TENNYSON AND BROWNING (3)
536. HENRY JAMES (3) The development of James as critic, novelist, and short story writer.
540. STUDIES IN ELIZABETHAN PROSE AND POETRY (3-6)
541. MEDIEVAL STUDIES (3-6) Special problems in medieval English literature.
542. MIDDLE ENGLISH LITERATURE (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer.
543. STUDIES IN EARLY SEVENTEENTH-CENTURY LITERATURE (3-6) Major poets and prose writers from 1600 to 1660.
544. RESTORATION LITERATURE (3) Selected studies of writers in England between 1650 and 1700.
545. CHAUCER (3-6) Critical study of the *Canterbury Tales* or *Troilus and Criseyde* and minor poems.
546. MILTON (3) The poetry and prose of John Milton.
548. ELIZABETHAN AND JACOBEAN DRAMA (3-6) English drama from 1558 to 1642, exclusive of Shakespeare.
549. SHAKESPEARE (3-6) Special problems of sources, chronology, text, characterization, and motivation in the drama.
552. SWIFT AND POPE (3)
553. THE AGE OF JOHNSON (3) The work of Johnson and his circle.
554. STUDIES IN EARLY AMERICAN LITERATURE (3)
556. EIGHTEENTH-CENTURY BRITISH FICTION (3)
557. EARLY EIGHTEENTH-CENTURY BRITISH LITERATURE (3) Prose and poetry in the reign of Queen Anne, with special attention to periodical publications.
560. AMERICAN ROMANTICISM (3) The romantic movement in American literature of the mid-nineteenth century.
561. STUDIES IN THE ROMANTIC MOVEMENT (3-6)
562. STUDIES IN THE LITERATURE OF VICTORIAN ENGLAND (3-6)
564. STUDIES IN NINETEENTH-CENTURY AMERICAN LITERATURE (3) The major figures treated will vary from year to year.
573. STUDIES IN TWENTIETH-CENTURY BRITISH LITERATURE (3-6) Major writers and literary movements.
574. STUDIES IN TWENTIETH-CENTURY AMERICAN LITERATURE (3-6) Major writers and literary movements.
575. JAMES JOYCE (3-6) Alternate terms: *Ulysses* and *Finnegans Wake*. Knowledge of *Dubliners* and *A Portrait of the Artist* is assumed.
576. HEMINGWAY AND FAULKNER (3) The major works.
578. SHAW (3) The plays, prose writings, and literary influence of G.B.S.

579. T.S. ELIOT (3) Major works in poetry, criticism, and drama; pertinent scholarship and criticism.
580. ANGLO-AMERICAN APPLICATIONS OF FOLKLORE IN LITERATURE (3) A detailed examination of the nature of the folktale and its implications for literature as an oral genre. Prerequisite: a basic knowledge of folklore, as taught in Engl. 196, is assumed.
581. CONTEMPORARY LITERARY CRITICISM (3)
582. HAWTHORNE AND MELVILLE (3) Detailed study of the major works of both authors and of the relationship between the two men.
583. EMERSON AND THOREAU (3) The significant prose and poetry of the chief American transcendentalists.
584. WHITMAN AND DICKINSON (3) The major texts, with special emphasis on background and language.
586. READINGS IN LITERATURE (1-12) Programs of readings designed to meet specific needs of individual students.
587. FRANKLIN AND EDWARDS (3) Studies in the lives, works, and milieu.
588. STUDIES IN AMERICAN FICTION (3-6)
589. STUDIES IN AMERICAN POETRY (3-6)
590. COLLOQUIUM (1-3)
592. STUDIES IN AMERICAN LITERARY MYTH (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture.
593. (C.Lit. 593) ANGLO-AMERICAN FOLK SONG (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present.
595. STUDIES IN BRITISH FICTION (3-6)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

ENTOMOLOGY (ENT)

BECKFORD F. COON, *Head of the Department*
106 Patterson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Benton, Cameron, Coon, Ercegovich, Hower, Kim, Mumma, Rutschky, Smilowitz, Smyth, Snetsinger, and Yendol.

Graduate Faculty: Associate Members Bode, Byers, Collison, and Jubb.

A student majoring in entomology may specialize in economic entomology, forest entomology, apiculture, insect resistance in plants, arachnology, medical or veterinary entomology, biological control, insect pathology, insect transmission of plant pathogens, ecology, morphology, embryology, taxonomy, physiology, insect behavior, or chemistry of pesticides.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one foreign language and proficiency in English.

For admission a student is required to have 24 credits in entomology and related biological sciences. Chemistry through organic, physics, mathematics through calculus, and statistics are required. A limited deficiency may be made up while pursuing graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENTOMOLOGY (ENT)

401. MEDICAL AND VETERINARY ENTOMOLOGY (3) *Mr. Kim*
409. INSECT BIOLOGY AND MANAGEMENT (3) *Mr. Rutschky*
412. FIELD ENTOMOLOGY (3) *Mr. Rutschky*
414. INSECT MORPHOLOGY AND PHYLOGENY (3) *Mr. Rutschky*
415. INSECT PHYSIOLOGY AND BIOCHEMISTRY (3) *Messrs. Mumma and Smyth*
416. METHODS FOR INSECT PEST POPULATION MANAGEMENT (3) *Mr. Hower*
418. FOREST ENTOMOLOGY (3) *Mr. Cameron*
425. FRESHWATER ENTOMOLOGY (3) *Mr. Kim*
435. ARACHNOLOGY (3) *Mr. Snetsinger*
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

515. INSECT MORPHOLOGY AND SYSTEMATICS (1-3) Current theories, controversies and advanced techniques in comparative morphology, histology, embryonic and postembryonic development, taxonomy and systematics of insects.
516. INSECT PHYSIOLOGY AND BIOCHEMISTRY (1-3) Selected topics in insect function and metabolism.
517. INSECT ECOLOGY AND BEHAVIOR (1-3) Selected aspects of the biotic and abiotic interactions of insects.
518. PEST MANAGEMENT (1-3) Current concepts and controversies in modern agricultural and urban pest management practice.
531. INSECT TOXICOLOGY (2) General principles of toxicology and survey of the actions of substances toxic to insects.
532. INSECT BEHAVIOR (2) Orientation reflexes, learning, communication, and social behavior; physiological bases; ecological and evolutionary implications.
535. BIOLOGICAL CONTROL (3) Practical and theoretical aspects of arthropod control by entomophagous insects and the place of biocontrol in integrated control programs.
536. INSECT PATHOLOGY (3) Diseases of arthropods and some aspects of microbial control of insects. Prerequisite: Micrb. 1.
542. (Biol. 542) SYSTEMATICS (3) Principles and methods of classification, phylogeny and speciation; taxonomic techniques; analysis of species, causal interpretation of animal diversity.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

ENVIRONMENTAL ENGINEERING (ENV E)

RAYMOND E. UNTRAUER, *Head of the Department of Civil Engineering*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Aron, Heinsohn, Long, McDonnell, Nesbitt, Reed, Untrauer, and Unz.

Graduate Faculty: Associate Members Chadderton, Kibler, Miller, and Regan.

This program prepares students for careers in (1) facility and system design; (2) systems management; (3) environmental monitoring; (4) process development; or (5) education and research in any of the environmental areas of water quality management (potable, industrial, and wastewater), water resources, management, and air pollution control.

The entering student normally should be a graduate from an accredited program in engineering.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Entering graduate students for whom English is not the first language are required to have a score of at least 575 on the TOEFL (Test of English as a Foreign Language) examination. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of one foreign language (French, German, Russian, or Spanish) and proficiency in English. A thesis is required for the M.S. degree. An engineering report is required for the M.Eng. degree.

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in environmental engineering (course descriptions are given under Civil Engineering): C.E. 451, 452, 462, 465, 471, 472, 474, 476, 551, 553, 564, 571, 572, 573, 574, 575, 577, 579, and 580. Appropriate courses offered by other departments include: Ag. 400; Ag.Ec. 442, 505; Bioch. 401, 402, 425; Biol. 410; Chem. 405; Cmp.Sc. 402; G.Sc. 452; I.E. 403, 405, 509, 510; M.E. 405, 470, 506, 521, 571; Meteo. 473, 502; Micrb. 400, 417; Nuc.E. 420; Pl.Sc. 419; P.Path. 424; Pub.A. 578; R.Pl. 400, 410, 510, 520.

ENVIRONMENTAL POLLUTION CONTROL (E P C)

JOHN B. NESBITT, *In Charge of Graduate Programs in Environmental Pollution Control*
226 Merrell R. Fenske Laboratory

Degrees Conferred: M.S., M.E.P.C., M.Eng.

Graduate Faculty: Senior Members Aplan, Aron, Baker, Bartlett, Barton, Cunningham, R. de Pena, Eagleton, Engel, Heicklen, Heinsohn, Hunt, Kabel, Knight, Kroger, Langmuir, Long, Lovell, McDonnell, McKee, Nesbitt, Palmer, Panofsky, Parizek, Petersen, Reethof, Risby, Simkovich, Sink, Stahl, Stephenson, Thomson, Unz, Witzig, and Zarkower.

Graduate Faculty: Associate Members Chadderton, DeTar, Ferguson, Goodwin, Kibler, Regan, and Thuering.

This intercollege program deals with the various aspects of the control of air and water pollution and the disposal of solid wastes. Graduate instruction is under the direction of an interdisciplinary faculty committee and the departments participating in the program. The faculty consists of the committee members listed above and a larger group of graduate faculty members with a teaching and/or research interest in the area of environmental pollution control.

Students are required to pass 9 credits of core courses: C.E. 472, Water Pollution Control; C.E. 476,

Solid Waste Management; and M.E. 470, Introduction to Air Pollution Control. In addition, they must select at least 21 of their total credits from a recommended course list and schedule the environmental pollution control seminars (E.P.C. 590) for three terms. If the option to prepare a thesis is selected, the research topic must be in the area of environmental pollution control and at least 6 credits of research must be taken in the department with which the student is affiliated. Students who select the nonthesis option must submit a paper. The student's adviser, the department head, and the E.P.C. program chairman determine the requirements of the paper.

Admission will be granted upon recommendation of the head of the academic department in which the student plans to complete a program and the environmental pollution control program faculty committee. Normal admission requirements include mathematics through integral calculus, plus one year of work in general physics and in chemistry. There is no foreign language requirement. Students with a 2.75 junior-senior average and with appropriate backgrounds in mathematics and science will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Entering graduate students for whom English is not the first language are required to have a score of at least 575 on the TOEFL (Test of English as a Foreign Language) examination.

ENVIRONMENTAL POLLUTION CONTROL (E P C)

590. COLLOQUIUM (1-3)

EXTENSION EDUCATION (EXTED)

DARYL K. HEASLEY, *Acting Chairman of the Committee on Extension Education*
204 Weaver Building

Degrees Conferred: M.Agr., M.Ed.

This program is designed primarily to meet the needs of professional teachers in various extension and adult education positions. The purpose is to train individuals to develop attitudes, understandings, and competences which enable them to become more effective professional workers. Options have been developed for the College of Agriculture. Additional options will be offered as they are developed by other colleges.

For either degree a minimum of 30 credits is required, including a professional paper. These credits should be distributed as follows: 12 credits in extension core courses, 6 in communication and/or education, and 12 in two areas of agriculture and/or home economics.

Admission requirements include a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

FOOD SCIENCE (FD SC)

DAVID R. LINEBACK, *Head of the Department*
111 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Beelman, Dimick, Keeney, Kroger, Lineback, MacNeil, Mason, McArdle, McCarthy, Patton, Sink, Thompson, and Ziegler.

Graduate Faculty: Associate Members Forsythe, Glass, Kilara, Kuhn, Mast, Molonon, and Ostovar.

Opportunities are available for study in the fields of food chemistry, biochemistry and metabolism, microbiology, quality control, flavor control and acceptance, rheology, and processing. Special emphasis can be devoted to dairy products, meats, plant products, and poultry products.

The requirements for the M.S. and Ph.D. programs are detailed in the Department of Food Science's publication, *Graduate Programs in Food Science*. The communication and foreign language requirement for the Ph.D. degree may be satisfied by demonstration of an intermediate knowledge of one foreign language or through completion of three courses in English language communication.

Prerequisite to graduate work is the completion of an undergraduate degree in food science, biochemistry, microbiology, or other related areas. The undergraduate program must include calculus, organic chemistry, microbiology, and general physics. Students may be admitted with deficiencies but are required to make them up without degree credit. Students who present a 3.00 junior-senior average will be considered for admission to the program, subject to the limitations of the physical facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

In addition to the courses listed below, the following courses are available in food science: A.I. 431; Ag.E. 412, 413, 414, 423, 503; A.Ntr. 401; D.Sc. 427; Hort. 528; Pty.Sc. 504.

FOOD SCIENCE (FD SC)

- 400. FOOD CHEMISTRY (3)
- 403. SANITATION AND QUALITY CONTROL (3)
- 404. SENSORY EVALUATION OF FOODS (2)
- 406. WINE TECHNOLOGY AND APPRECIATION (2)
- 407. FOOD TOXINS (2)
- 408. APPLIED FOOD MICROBIOLOGY (2)
- 409. LABORATORY IN APPLIED FOOD MICROBIOLOGY (2)
- 410. CHEMICAL METHODS OF FOOD ANALYSIS (4)
- 415. MEAT SCIENCE AND TECHNOLOGY (3)
- 421. TECHNICAL CONTROL PROBLEMS (1-6)
- 490. UNDERGRADUATE SEMINAR (1)

- 505. CONCEPTS OF PRODUCT DEVELOPMENT (3) Interrelationships of processing principles and chemical and physical properties in the development of new and improved food products.
- 507. FOOD QUALITY, FOOD STANDARDS, AND CONSUMER PROTECTION (2) Problems of the food industry relating to contamination and quality of food products.
- 510. SEMINAR IN FOOD SCIENCE (1-6)
- 515. EXPERIMENTAL MEAT SCIENCE AND MUSCLE BIOLOGY (2-6) Experimental and theoretical aspects of meat science, meat product/process systems, and the quantitative biology of muscle systems used for food. Prerequisite: Fd.Sc. 400 or 415.
- 520. PROBLEMS IN FOOD SCIENCE (1-9) Special problems in dairy, horticultural, meat, poultry, and other food products.
- 521. RADIOBIOLOGY (3) Radioactivity: its nature, interaction with matter, measurement, and quantification; the use of isotopes as tracers in biological systems.

522. **RESEARCH PROCEDURES IN FOOD SCIENCE (3)** Research problems and methods in food science with major emphasis on food chemistry.

602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

FOREST RESOURCES (FOR R)

ROBERT S. BOND, *Director of the School of Forest Resources*
101 Ferguson Building

Degrees Conferred: Ph.D., M.S., M.F.R.

Graduate Faculty: Senior Members Blankenhorn, Bond, DeWalle, George, Gerhold, Hutnik, Lindzey, Shipman, Sopper, Turner, and Ward.

Graduate Faculty: Associate Members Baldwin, Bowersox, Johnson, Kelly, Kersavage, Lynch, McCormick, Rader, Reyburn, Steiner, Storm, Strauss, and Wakeley.

The Doctor of Philosophy and the Master of Science degree programs are oriented toward research, education, and scientific technology in the professions of forest products, forestry, and wildlife management. The foreign language requirement for the Ph.D. degree may be satisfied by demonstrating competence in one foreign language equivalent to passing three college-level courses.

The Master of Forest Resources is a professional degree which emphasizes application of knowledge through managerial practices involving forest resources, industries, or the natural environments of communities and recreational areas.

A thesis is required for the M.S. and Ph.D. degrees, and an original paper for the M.F.R. degree. Most programs of study are strengthened by including appropriate courses offered by related departments.

Faculty expertise, laboratories, and outdoor research facilities are available to support specialization in a variety of fields. Possibilities for specialization are indicated in part by the courses listed under forest products, forestry, and wildlife, and by related courses in agricultural economics, agronomy, animal nutrition, biology, business administration, chemical engineering, computer science, ecology, economics, entomology, environmental pollution control, environmental resource management, genetics, horticulture, industrial engineering, landscape architecture, meteorology, physiology, plant pathology, polymer sciences, recreation and parks, regional planning, or statistics.

For admission, an applicant should have at least a 2.75 grade-point average, a 3.00 junior-senior average, and courses that are basic to the individual's field of specialization. Ordinarily these include 12 credits in communication, 12 credits in social sciences and humanities, 12 credits in quantification including calculus and statistics, 9 credits in physical sciences, 9 credits in biological sciences, and 18 credits in forest products, forestry, wildlife, or related courses. Graduate Record Examination scores and three reference reports (forms supplied on request) are required, and a brief statement describing the applicant's academic goals, career interests, and special qualifications. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to admission requirements may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

FOREST PRODUCTS (F P)

- 401. **WOOD SCIENCE CONCEPTS (2)**
- 402. **WOOD SCIENCE PRACTICUM (1)**
- 411. **WOOD-ENVIRONMENTAL RELATIONSHIPS (3)**
- 412. **WOOD IN STRUCTURES (3)**
- 413. **THE CHEMISTRY OF WOOD (3)**
- 414. **PULP AND FIBER TECHNOLOGY (3)**
- 420. **PROCESSING AND MACHINING OF WOOD AND WOOD PRODUCTS (2)**

- 421. GLUING AND FINISHING WOOD (2)
 - 422. DRYING OF WOOD (2)
 - 423. DETERIORATION AND PROTECTION OF WOOD PRODUCTS (2)
 - 424. COMPOSITE WOOD PRODUCTS (2)
 - 430. FOREST PRODUCTS MANUFACTURING SYSTEMS (3)
 - 435. FOREST PRODUCTS PRODUCTION MANAGEMENT (3)
 - 439. PULP AND TIMBER HARVESTING (3)
 - 490. FOREST PRODUCTS COLLOQUIUM (1)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
502. WOOD FIBERS (3) Identification and measurement of physical and chemical characteristics of wood fibers used in paper or dissolving pulps.
511. PHYSICAL PROPERTIES OF WOOD AND FIBERS (2) Theories of accessibility, sorption, dimensional stabilization, diffusion, and permeability of cellulosic fibers and solid wood. Prerequisite: F.P. 411.
513. WOOD CHEMISTRY (3) Treatment of the chemical components of wood, their distribution and reactions. Prerequisite: F.P. 413.
530. FOREST PRODUCTS INDUSTRIAL OPERATIONS ANALYSIS (2) Research methods with emphasis on programming, simulation, and waiting line problems. Prerequisite: F.P. 495.
531. MECHANICAL BEHAVIOR OF WOOD (3) Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.
532. THEORY OF ADHESION (3) Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

FORESTRY (FOR)

- 403. DENDROLOGY (3)
 - 416. FOREST RECREATION (3)
 - 421. SILVICULTURE (3)
 - 440. FOREST ECONOMICS AND FINANCE (3)
 - 450. INTRODUCTION TO OPERATIONS RESEARCH (3)
 - 455. AERIAL PHOTOS IN FORESTRY (3)
 - 466. FOREST RESOURCE MANAGEMENT (3)
 - 480. POLICY AND ADMINISTRATION (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
508. FOREST ECOLOGY (3) The forest ecosystem, variations in space and time, classification, ordination techniques, dynamic aspects such as energy flow and nutrient cycling.
512. FOREST GENETICS (3) Qualitative and quantitative genetic principles and research methods applied in tree breeding.
517. FOREST MICROCLIMATOLOGY (3) A quantitative treatment of climate near the ground, with special reference to the role of forests and terrain. Prerequisite: Phys. 202.
519. FOREST HYDROLOGY (3) Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisites: For. 308, C.E. 51.

521. **ADVANCED SILVICULTURE (3)** Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.
525. **FOREST LAND USE (3)** Concepts of supply and demand for forest lands and their allocation to alternative uses. Prerequisites: For. 466 or Ag.Ec. 421; or Geog. 405 and 3 credits in economics.
550. **DESIGN AND ANALYSIS OF EXPERIMENTS (3)** Specialized techniques involved in the design and analysis of complex forestry research problems. Prerequisite: For. 450.
560. **TIMBER MANAGEMENT (3)** Technical methods in the organization and control of the forest property for timber production.
575. **APPLICATIONS OF FOREST ECONOMICS AND FINANCE (3)** Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 440.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

NOTE: See also *Wildlife Management*.

FRENCH (FR)

RICHARD L. FRAUTSCHI, *Head of the Department*
316 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A.

Graduate Faculty: Senior Members Belasco, Brault, Chapman, Frautschi, Norton, and Ward.

Graduate Faculty: Associate Members Ariew, Danahy, Hale, Knight, Makward, and Saunders.

This program offers training in language, literature, linguistics, and civilization. A candidate for the M.A. degree may select a program of study emphasizing language with cultural emphasis or literature. A reading knowledge of a second foreign language and written and oral comprehensive examinations are required. The candidate may submit either a thesis or a term paper. If the latter is chosen, 6 additional credits in 500-level courses must be scheduled. The M.A. degree (or equivalent) is normally a prerequisite to doctoral candidacy.

The D.Ed. degree is structured for students preparing careers emphasizing teaching, curriculum design, and administration in secondary and post-secondary education. Of the 90 required graduate credits, a minimum of 60 (including M.A. credits) must be acquired in French courses and another 15 in the College of Education. A reading knowledge of a second foreign language is also required. A thesis focusing on a pedagogical topic is selected and may be supervised by faculty in both French and education.

The Ph.D. degree prepares candidates for careers in teaching and research at the college level. A minimum of 66 credits (including M.A. credits) is required in graduate course work, 36 of which must be distributed in metropolitan literature. Candidates may specialize in French literature, linguistics, francophone literature, or, with special permission, interdisciplinary study in the humanities, social sciences, or fine arts. The communication and foreign language requirement for the Ph.D. degree may be satisfied by at least a reading knowledge of two foreign languages other than French.

The minimum requirement for admission to an advanced degree program will normally be 36 credits of post-intermediate work in language and literature. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. A brief tape recording of an

original composition in French must be presented before admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

FRENCH (FR)

*1G. ELEMENTARY FRENCH FOR GRADUATE STUDENTS (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. ELEMENTARY FRENCH FOR GRADUATE STUDENTS (3) Continuation of Fr. 1G with reading practice.

500. INTRODUCTION TO OLD FRENCH (3) Analysis of the phonology, morphology, and syntax of Old French based on early literary monuments. *Mr. Brault*

503. FRENCH PHONOLOGY (3) Articulatory and acoustic correlates of distinctive features; synchronic dialectology; phonology in generative grammar. *Mr. Belasco*

504. FRENCH MORPHOLOGY AND SYNTAX (3) Principles of segmentation and decomposition; tagmemics and transformation theory; morphophonemics. *Mr. Belasco*

505. SEMANTIC THEORY OF THE FRENCH LANGUAGE (3) The goals of semantic description; systematic interrelation of semantic generalizations; empirical and methodological constraints. *Mr. Belasco*

510. STYLISTIQUE AVANCÉE (3) Study of rhetorical figures and expository style in prose and poetry through *dissertation* and *explication*.

511. READINGS IN OLD FRENCH (3 per term, maximum of 6) A survey of French literature to 1300, focusing in alternate terms on either the 12th or the 13th century. *Mr. Brault*

512. LATE MEDIEVAL FRENCH LITERATURE (3) The non-dramatic literary genres of the late Middle Ages, with reference to their cultural context and social function. *Mr. Knight*

516. THE SONG OF ROLAND (3) Seminar in the Old French *Chanson de Roland*, with emphasis on the problems of textual criticism and literary analysis. *Mr. Brault*

518. MEDIEVAL FRENCH DRAMA (3) The development of French drama from its liturgical origins to the flourishing comic theatre of the late Middle Ages. *Mr. Knight*

526. AGE OF RABELAIS (3) Notions of literary creativity in the context of early sixteenth-century French Humanism: readings from Rabelais, Marguerite de Navarre, Scève. *Mr. Norton*

528. AGE OF MONTAIGNE (3) Literary culture of Renaissance France in the context of social and political crisis; readings from Montaigne, DuBellay, Ronsard, and Sponde. *Mr. Norton*

533. SEVENTEENTH-CENTURY PROSE AND POETRY (3) The development of classicism; its apogee and decline as seen in the works of major prose writers and poets. *Mr. Chapman*

534. MOLIÈRE (3) The literary achievement of Molière, the comic playwright, director, actor, and founder of the Comédie Française. *Mr. Chapman*

535. SEVENTEENTH-CENTURY FRENCH TRAGEDY (3) The development and triumph of tragedy as a literary genre with special emphasis on the achievement of Corneille and Racine. *Mr. Chapman*

540. VOLTAIRE AND HIS CONTEMPORARIES (3) The artistic and philosophical evolution of Voltaire as seen in the tragedy, the philosophical tale, and poetry. *Mr. Frautschi*

541. ROUSSEAU AND HIS CONTEMPORARIES (3) Rousseau's rationalistic critique of civilization; his sentimental rehabilitation of the individual, family, state; Rousseau, precursor of romanticism. *Mr. Frautschi*

*No graduate credit is given for this course.

- 561. FRENCH ROMANTICISM (3) The romantic movement in French literature with emphasis upon its major exponents in prose and poetry. *Mr. Danahy*
- 563. FRENCH REALISM (3) The realistic movement in French literature with emphasis upon its major exponents in prose and poetry. *Mr. Danahy*
- 565. THE NINETEENTH-CENTURY FRENCH NOVEL (3) The development of the novel in the nineteenth century with emphasis on Constant, Balzac, Stendhal, Flaubert, and Zola. *Mr. Danahy*
- 567. TWENTIETH-CENTURY FRENCH THEATRE (3) Evolution of the French theatre from the plays of the *belle époque* to the avant-garde works of today. *Mrs. Makward*
- 568. BAUDELAIRE (3) A study of his poetry and his criticism.
- 569. MASTERS OF TWENTIETH-CENTURY FRENCH LITERATURE (3-6) Major literary figures of contemporary French literature. *Mrs. Makward*
- 571. FRENCH LITERARY CRITICISM FROM SAINTE-BEUVE TO PRESENT (3) Evolution of French literary criticism from Sainte-Beuve, the "father" of modern literary criticism, to contemporary critics.
- 580. SEMINAR IN FRENCH LITERATURE (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor.
- 581. THEORY AND TECHNIQUES OF TEACHING FRENCH (1-6)
- 586. SYMBOLISM (3) The anti-positivistic tradition in nineteenth-century French literature dealing with the Symbolist School; its antecedents and its subsequent ramifications.
- 587. RESEARCH TECHNIQUES AND BIBLIOGRAPHY IN FRENCH LANGUAGE AND LITERATURE (1-3)
- 595. ANALYSIS OF FRENCH CIVILIZATION (3-6) French cultural aspects, other than language and literature, conducted in French with the collaboration of specialists outside the French department.
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

FUEL SCIENCE (F SC)

PHILIP L. WALKER, JR., *In Charge of Graduate Programs in Fuel Science*
101 Steidle Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Austin, Given, Palmer, Vastola, and Walker.

Graduate Faculty: Associate Member Becker.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree.

Well-instrumented research facilities are available for investigation of the chemical and physical characteristics of coals, fundamentals of coal gasification and liquefaction, flame dynamics in practical combustion systems, industrial fuel efficiency, chemistry and physics of basic combustion phenomena, chemical kinetics of fast gaseous reactions, formation and removal of polluting species in combustion processes, physics and chemistry of carbonaceous solids, organic geochemistry of plant-derived sediments, modeling of energy systems, electrochemical energy conversion, and solar power generation. Students can plan a wide variety of programs of study to suit individual needs; coherent interdisciplinary programs are encouraged. The nonthesis option is available for the M.S. degree.

Competency in a foreign language is not required for the Ph.D. degree. Candidates are expected to demonstrate high proficiency in both written and spoken English.

Applications will be accepted from persons having degrees in the basic or applied physical sciences or in engineering. Students with a 2.75 junior-senior average normally will be considered for admission. Exceptions may be made for students with special abilities, interests, or backgrounds, such as extensive industrial experience in fuels or combustion.

FUEL SCIENCE (F SC)

- 421. FLAMES (3) *Mr. Palmer*
 - 422. COMBUSTION ENGINEERING (3)
 - 424. ENERGY AND FUELS IN TECHNOLOGICAL PERSPECTIVE (3) *Mr. Vastola*
 - 430. AIR POLLUTANTS FROM COMBUSTION SOURCES (3)
 - 431. THE CHEMISTRY OF FUELS (3) *Mr. Given*
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
506. CARBON REACTIONS (3) Current approaches to heterogeneous reactions in combustion and gasification of carbonaceous solids, including those derived from coal and petroleum sources. Prerequisite: Chem. 452. *Mr. Walker*
512. HIGH-TEMPERATURE KINETICS AND FLAME PROPAGATION (3) Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high-temperature gases. Prerequisite: F.Sc. 421. *Mr. Palmer*
520. THERMODYNAMICS AND KINETICS OF FUEL EFFICIENCY (3) Thermodynamic and kinetic constraints on efficiencies of thermal systems; efficiency ratios; furnace analysis; radiation in furnaces, applications and examples. Prerequisite: study of thermodynamics at the upperclass or graduate level.
522. FLAME DYNAMICS IN COMBUSTORS (3) Mixing and reaction in combustion chambers; combustor analysis; residence time distributions; perfectly and well-stirred combustors; models and experiments.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

NOTE: Courses in the use of X-ray diffraction, electron microscopy, spectroscopy, and electronic instrumentation in fuel science studies are listed under Materials Science.

GENETICS (GENET)

PAUL W. TODD, *Chairman of the Committee for the Program in Genetics*
403 Althouse Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Ayers, Berlin, Buss, Cleveland, Craig, Davidson, Deering, Docherty, Fritz, Gerhold, Ginoza, Goodwin, Grun, Hargrove, C. W. Hill, R. R. Hill, Hunt, Jacob, Jones, Keith, Lang, MacCluer, MacKenzie, Marshall, R. Nelson, Person, Rapp, Rosenberg, Shannon, Snipes, Starling, J. Taylor, W. Taylor, Therrien, Todd, Vesell, Wilson, Wright, Zagon, and Zimmerman.

Graduate Faculty: Associate Members Carter, Dachtler, Dyke, Eckhardt, Garwood, Hepler, Johnson, Ladda, Liu, Pfeifer, Risius, Schengrund, Schlegel, Shenk, S. Smith, Steiner, Stevens, Thoele, and Yasbin.

The program for genetics is an intercollege one, and faculty from the Colleges of Agriculture, the Liberal Arts, Medicine, and Science serve as major advisers and on committees for the majors. The student is encouraged to select a major adviser. Courses may be taken at either The Milton S. Hershey Medical Center or University Park.

Opportunities for graduate study and research are available in biochemical, developmental, human, microbiological, viral, molecular, and population genetics; cytogenetics; and pharmacogenetics. Organisms available for research include fungi, bacteria, viruses, fish, rodents, birds, man, forest trees, and grain, forage, and horticultural plants. The graduate faculty committees for majors have the responsibility and jurisdiction for determining course work, specific requirements in communication skills exceeding the minimum, and research acceptable for satisfying degree requirements. The requirement in communication and foreign language skills for the Ph.D. degree may be satisfied by fulfilling the requirement of the thesis adviser's department or program.

Students with a grade-point average of 3.00 or better and with appropriate course backgrounds in biology, science, and communications courses will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Students with limited deficiencies may be admitted, but they must make up such deficiencies concurrently with their graduate studies.

The following genetics courses are available: Agro. 411, 509, 510, 511; An.Sc. 422, 455; Bioch. 513; Biol. 422, 426, 427, 428, 465, 533; B.Chem. 503; Bphys. 430, 582, 589; C.Med. 503; For. 512; Hort. 407, 444, 507; Micrb. 516; Micro. 553, 556; Pharm. 515, 540; P.Path. 543. Twelve credits in these courses, including at least 3 credits in acceptable statistics courses, and 1 credit in genetics seminar (Biol. 524 or Pharm. 515) are required for the M.S. degree in genetics or a minor in genetics for a Ph.D.; 15 credits in these courses and 1 credit per year in genetics seminar are required for a Ph.D. major in genetics. Certain transfer credits for courses in genetics may be accepted as substitutes for the above-listed courses.

GEOGRAPHY (GEOG)

RONALD ABLER, *Head of the Department*
403A Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Abler, Downs, Erickson, Gould, Knight, Lewis, Miller, Rodgers, Simkins, Wernstedt, Williams, Yapa, and Zelinsky.

Graduate Faculty: Associate Member Goodwin.

The student may concentrate in subjects that call upon the special skills and interests of the staff. At the present time these include the American landscape, behavioral geography, communication systems, cultural geography of Anglo-America, cultural geography of Southeast Asia, environmental pollution control, geographic analysis, geography of the developing world, geographic theory, human geography of the U.S.S.R., human use of environment, industrial location, macrospatial analysis in regional and urban development, population problems, and regional economic development. All students receive training in cartographic and statistical techniques.

For the M.S. degree, the student has the option of completing a thesis or two papers. The master's program is broadly based, designed to provide a beginning graduate student with basic training in systematic fields, as well as in geographic theory and research techniques. This basic training underlies more specialized study at the doctoral level, where a candidate selects two fields of concentration. A student may elect to specialize in the geography of a region only if faculty members have research experience in that region. The communication and foreign language requirement for the Ph.D. degree shall be satisfied in a manner approved by the candidate's doctoral committee.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

Qualified students also may select population issues as an optional area of specialization. In addition to departmental admission requirements, the Population Issues Committee evaluates the student's interest and aptitude for the training program, which consists of a minimum of 21 credits of interdisciplinary course work in population.

GEOGRAPHY (GEOG)

401. HISTORICAL GEOGRAPHY OF NORTH AMERICA (3) *Mr. Lewis or Mr. Zelinsky*
402. CULTURAL AND ANTHROPOGEOGRAPHY (3) *Mr. Zelinsky*
405. GEOGRAPHY OF POPULATION (3) *Mr. Simkins or Mr. Zelinsky*
406. HUMAN USE OF ENVIRONMENT (3) *Mr. Goodwin or Mr. Knight*
410. CARTOGRAPHY — MAP DESIGN AND CONSTRUCTION (3)
411. ADVANCED CARTOGRAPHY (3) *Mr. Abler*
412. THE GEOGRAPHY OF THE FUTURE (3) *Mr. Abler*
413. BEHAVIORAL APPROACHES TO GEOGRAPHY (3) *Mr. Downs*
416. LOW-ENERGY LIVING (3) *Mr. Goodwin*
420. URBAN GEOGRAPHY (3) *Mr. Erickson*
427. GEOGRAPHY OF THE SOVIET UNION (3) *Mr. Rodgers*
433. REGIONAL CLIMATOLOGY (3) *Mr. Wernstedt*
434. REGIONAL PHYSIOGRAPHY (3) *Mr. Lewis*
440. GEOGRAPHY OF MIDDLE AMERICA (3) *Mr. Simkins*
441. GEOGRAPHY OF SOUTH AMERICA (3) *Mr. Simkins*
442. REGIONAL SYSTEMS IN EUROPE (3) *Mr. Miller*
443. GEOGRAPHY OF THE ORIENT (3) *Mr. Wernstedt*
444. GEOGRAPHY OF AFRICA (3) *Mr. Knight*
445. GEOGRAPHY OF SOUTHERN ASIA (3) *Mr. Wernstedt*
450. DEVELOPMENT OF GEOGRAPHIC THOUGHT (3) *Mr. Abler*
451. MAP INTERPRETATION (3) *Mr. Lewis*
452. INTERPRETATION OF AERIAL PHOTOGRAPHS (3) *Mr. Goodwin*
454. SPATIAL ANALYSIS I (3) *Mr. Gould or Mr. Williams or Mr. Yapa*
455. SPATIAL ANALYSIS II (3) *Mr. Gould or Mr. Williams or Mr. Yapa*
457. GEOGRAPHIC DATA SYSTEMS (4) *Mr. Williams*
460. POLITICAL GEOGRAPHY (3) *Mr. Lewis or Mr. Williams*
470. INDUSTRIAL LOCATION AND DEVELOPMENT (3) *Mr. Rodgers*
475. GEOGRAPHY OF COMMUNICATIONS SYSTEMS (3) *Mr. Abler*
495. DIRECTED READINGS (1-9)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. INTRODUCTION TO GEOGRAPHIC RESEARCH (3)
502. REGIONAL THEORY (3) Taxonomic methods of uniform-functional regionalization; canonical linkages; intraregional relationships; Wilson models of macrocanonical ensembles.
503. ADVANCED REGIONAL GEOGRAPHY (3-12) Intensive study at an advanced level of selected regions or sections of the continents. Prerequisite: 12 credits in geography.
504. PHYSICAL GEOGRAPHY SEMINAR (3-12) The examination of current problems and theories in physical geography through critical discussion of the literature and student research.
505. ECONOMIC GEOGRAPHY SEMINAR (3-12) The examination of current problems and theories in economic geography through critical discussion of the literature and original student research.
508. CULTURAL GEOGRAPHY SEMINAR (3-6) The exploration of current problems and theory in cultural geography through critical discussion of the literature and original student research.
509. POPULATION GEOGRAPHY SEMINAR (3) Selected problems in population geography with emphasis on analysis and presentation of data. Prerequisite: Geog. 405.
510. ANALYTIC CARTOGRAPHY (3) Computer graphics, geographical matrix operations, response

functions, sampling resolution, quantization, map generalization, pattern recognition, generalized spatial partitionings, and map projections. Prerequisites: Geog. 454, 455.

517. GEOGRAPHIC MODELING (1) Spatial modeling, mapping and transformations of elementary geographic problems.

520. METROPOLITAN ANALYSIS (3) Land use models, urban factorial ecology; intraurban movements; urban renewal, ghetto structure, residential change; commercial structure, blight. Prerequisite: Geog. 420 or 454.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

GEOSCIENCES

C. WAYNE BURNHAM, *Head of the Department*
204 Deike Building

There are three graduate degree programs to which a student can be admitted: geochemistry and mineralogy, geology, and geophysics. Transfer from one of these majors to another is possible, provided the basic admission requirements of the program into which the student is transferring are met.

For admission applicants are required to submit the results of the Graduate Record Examination and are generally expected to have a bachelor's degree in some branch of the natural or physical sciences, engineering, or mathematics. An applicant also is expected to have completed standard introductory courses in geosciences, chemistry, physics, and mathematics through integral calculus, plus 15 credits of intermediate-level work in one or a combination of these subjects. Greater than minimal preparation within these limits may be required in chemistry and mineralogy for the geochemistry and mineralogy major; in geology and biology for the geology major; and in mathematics and physics for the geophysics major. Applicants who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies. Students with special backgrounds, abilities, and interests whose undergraduate grade-point average in courses pertinent to geosciences is below a 3.00 will be considered for admission only when there are strong indications that a 3.00 average can be maintained at the graduate level. The foreign language requirement for the Ph.D. degree may be satisfied by elementary competence in two languages other than English or by comprehensive competence in one. The student has the option of a thesis or a paper for the M.S. degree.

GEOLOGICAL SCIENCES (G SC)

403. GEOLOGICAL ASPECTS OF ENVIRONMENTAL PROBLEMS (3) *Mr. Dachille*

404. GEOLOGY OF THE SOLAR SYSTEM (3)

408. (Mat.Sc. 408) X-RAY DIFFRACTION (3) *Mr. Dachille*

409. OPTICAL MINERALOGY (3) *Mr. Kerrick*

411. (Mat.Sc. 411) INSTRUMENTAL TECHNIQUES APPLIED TO MATERIALS AND MINERAL SCIENCES PROBLEMS (1-6)

Unit A. X-RAY DIFFRACTION

Unit B. TRANSMISSION ELECTRON MICROSCOPY

Unit C. SPECTROSCOPY

Unit D. ELECTRON MICROPROBE ANALYSIS

Unit E. SCANNING ELECTRON MICROSCOPY

Unit F. ABSORPTION SPECTROSCOPY

416. STABLE AND RADIOACTIVE ISOTOPES IN GEOSCIENCES: INTRODUCTION (3) *Messrs. Dachille and Deines*

- 419. INTRODUCTION TO ORGANIC GEOCHEMISTRY (3) *Mr. Given*
- 420. (Biol. 420) PALEOBOTANY (3) *Mr. Spackman*
- 421. INTRODUCTION TO COAL PETROLOGY (3) *Mr. Davis*
- 422. COAL MEASURE GEOLOGY (3) *Mr. Davis*
- 423. (Biol. 423) INTRODUCTORY PALYNOLOGY (3) *Mr. Traverse*
- 425. PALEONTOLOGY (3) *Mr. Guber*
- 426. PALEOECOLOGY (3) *Mr. Cuffey*
- 427. (Biol. 427) EVOLUTION (3) *Messrs. Cuffey and Traverse*
- 432. PETROLOGY (3) *Messrs. Kerrick and Thornton*
- 434. VOLCANOLOGY (3) *Mr. Thornton*
- 436. PETROLOGY AND GEOCHEMISTRY OF SEDIMENTS (3) *Messrs. Langmuir and Williams*
- *439. STRATIGRAPHY (3) *Messrs. Cuffey and Williams*
- 440. MARINE GEOLOGY (3) *Mr. Schmalz*
- 442. EVOLUTION OF COASTLINES (3) *Mr. Slingerland*
- 445. COASTAL GEOLOGY (4) *Messrs. Guber, Schmalz, Slingerland, and Williams.*
- 451. ECONOMIC GEOLOGY (3) *Messrs. Gold and Rose*
- 452. INTRODUCTION TO HYDROGEOLOGY (3) *Messrs. Langmuir and Parizek*
- 454. GEOLOGY OF OIL AND GAS (3) *Mr. Scholten*
- 457. GEOCHEMICAL EXPLORATION (3) *Mr. Rose*
- 461. GEOLOGY OF NORTH AMERICA (3) *Mr. Wright*
- *462. PRINCIPLES OF GEOMORPHOLOGY (3-6) *Mr. Potter*
- 465. STRUCTURAL GEOLOGY (3) *Mr. Gold*
- 466. MECHANICS OF GEOLOGICAL MATERIALS (3) *Mr. Voight*
- *470. INTRODUCTION TO FIELD GEOLOGY (3) *Messrs. Gold and Wright*
- *471. FIELD STUDIES IN NORTH AMERICA (3)
- 472. FIELD GEOLOGY (5)
- 480. PHYSICS OF THE EARTH (3) *Mr. Graham*
- 482. GEOPHYSICAL WELL LOGGING (3) *Mr. Lavin*
- 484. GEOPHYSICAL SURVEYING (3)
- 487. ANALYSIS OF TIME SERIES (3) *Mr. Lavin*
- 488. POTENTIAL THEORY APPLIED TO EARTH PROBLEMS (3) *Mr. Alexander*
- 490. GEOLOGICAL SCIENCES SEMINAR (1-6 per term)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 547. EVOLUTION IN ECOSYSTEMS (3) Evolutionary attributes of ecosystems; manifestation of evolutionary mechanisms in ecological systems; evolution of interspecies integrations; evolution of selected ecosystems.

- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

*This course includes from one to several field trips for which an additional charge will be made.

GEOCHEMISTRY AND MINERALOGY (G M)

DERRILL M. KERRICK, *In Charge of Graduate Programs in Geochemistry and Mineralogy*
211 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barnes, Burnham, Dachille, Deines, Kerrick, Langmuir, Muan, Ohmoto, Rose, Roy, Smith, Thornton, and White.

Graduate Faculty: Associate Members Egglar, Lasaga, and Suhr.

Areas of specialization include phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical exploration, cosmochemistry, high-temperature and high-pressure geochemistry, ore-forming processes, igneous, sedimentary, and metamorphic petrology, experimental petrology and mineralogy, crystallography, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

MINERALOGY (MIN)

402. MINERALOGY AND PETROLOGY FOR TEACHERS (3) *Mr. Thornton*

GEOCHEMISTRY AND MINERALOGY (G M)

502. (Geol. 502) CARBONATES IN THE MARINE ENVIRONMENT (3) Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach.

503. (Mat.Sc. 503) KINETICS OF MATERIALS PROCESSES (3) Introduction to application of transition state theory and mass transfer to the kinetics of materials and mineral processes. Prerequisites: Math. 100, Chem. 451; G.M. 521 or Mat.Sc. 501.

510. METAMORPHIC PETROLOGY (2-4 per term, maximum of 6) Detailed review of chemical, mineralogical, and structural changes that take place during metamorphism. Prerequisite: Min. 483, 484. *Mr. Kerrick*

512. (Mat.Sc. 512) PRINCIPLES OF CRYSTAL CHEMISTRY (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions. *Mr. Roy*

*513. SCIENTIFIC METHOD IN GEOSCIENCE (3) Problem formulation, sampling designs, selection of variates, and comparison of techniques for analysis of aggregates. *Mr. Potter*

*514. STATISTICAL AND ELECTRONIC DATA PROCESSING PROCEDURES FOR GEOSCIENCE (3) Statistical analysis of experimental data using univariate and bivariate procedures. *Mr. Potter*

*515. ORE MICROSCOPY (3) Optical and hardness measurements and phase equilibria as used in identification and interpretation of textures of ore minerals. *Mr. Barnes*

*517. AGE DETERMINATIONS (1-2) Geochemistry of radioactive elements and their daughters; age determination techniques and observations. *Mr. Deines*

518. STABLE ISOTOPE GEOCHEMISTRY (3) Theory of isotope fractionation mechanisms; its application to a wide range of problems in the earth and planetary sciences. *Mr. Deines*

519. PHASE EQUILIBRIA IN MINERAL SYSTEMS AT HIGH TEMPERATURES (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams. *Mr. Muan*

*Offered alternate years.

520. P-T-X PHASE EQUILIBRIA (3) Phase equilibrium in mineral systems with pressure as a variable. *Mr. Egger*
521. MINERAL EQUILIBRIA (3) A thermodynamic treatment of minerals and their reactions under geochemically important conditions of temperature and pressure. Prerequisite: Chem. 451. *Messrs. Muan and Lasaga*
522. GEOCHEMISTRY OF AQUEOUS SYSTEMS (2-3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, PO₂-pH relations applied to ground water, sea water, hydrothermal fluids. Prerequisites: Chem. 451-452; G.Sc. 432, 436. *Messrs. Barnes and Schmalz*
- *523. WATER-RESOURCE GEOCHEMISTRY (2-4) Topics and problems concerning the chemical quality of surface waters and ground waters related to hydrogeologic and cultural controls. *Mr. Langmuir*
- *524. (Mat.Sc. 524) VIBRATIONAL SPECTRA OF MATERIALS AND MINERALS (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization and glass research. Prerequisites: Phys. 412, 471. *Mr. White*
- *525. ELECTRON PROPERTIES OF MINERALS (2) Application of spectroscopy to mineralogy, crystal field, EPR, NMR, Mossbauer spectra. Application to order-disorder, element distribution, mineral stability. Prerequisites: Phys. 412, 471. *Mr. White*
526. PROBLEM SOLVING IN GEOSCIENCE (3) Multivariate statistical analysis, decision making, operations research, and systems analysis in geoscience.
- *527. MINERALOGY I—SILICATES (3) Detailed study of the crystal structures and crystal chemistry of the silicate minerals. *Mr. Smith*
- *528. MINERALOGY II—NONSILICATES (3) Detailed study of the crystal structures and crystal chemistry of the nonsilicate minerals. *Mr. Smith*
530. (Cer.Sc. 530) STRUCTURE, PROPERTIES, AND OCCURRENCE OF CLAY MINERALS (2-5) Structure analysis and identification of clay minerals; mineral transformations and behavior; occurrence, genesis, and petrography of fine-grained sediments.
- *531. (Mat.Sc. 531) TRANSMISSION ELECTRON MICROSCOPY (2) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences. Prerequisite: Min. 411B (Mat.Sc. 411B). *Mr. Throver*
- *532. (Mat.Sc. 532) STRUCTURE ANALYSIS (2) Crystal structure determination methods; space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: G.Sc. 408 (Mat.Sc. 408). *Mr. Smith*
- *533. (Mat.Sc. 533) SINGLE CRYSTAL METHODS (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: G.Sc. 408 (Mat.Sc. 408). *Mr. Ryba*
- *534. (Mat.Sc. 534) DIFFRACTION BY CRYSTALS (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescence, polarization. Prerequisite: G.Sc. 408 (Mat.Sc. 408). *Mr. McKinstry*
- *535. (Mat.Sc. 535) GEOMETRICAL CRYSTALLOGRAPHY (3) Derivation of lattices, types, point groups, and space groups, with applications. *Mr. Smith*
- *538. (Mat.Sc. 538) ELECTRON BEAM ANALYSIS OF SOLIDS VIA X-RAY AND ELECTRON EMISSION (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids.
540. METEORITICS (2) Mineralogy, petrology, and chemistry of meteorites; theories of their origin and formation. Prerequisite: G.Sc. 432.
542. ELEMENT DISTRIBUTION IN THE EARTH (3) Principles and data from studies of phase equilib-

*Offered alternate years.

ria, petrology and crystal structure as related to distribution of elements in minerals, rocks, and the earth.

550. **IGNEOUS PETROLOGY (2-3)** Magmatic processes and their expression in the mineralogy, major and trace element chemistry, and isotopic composition of igneous rocks. Prerequisite: G.Sc. 432. *Mr. Thornton*

551. **PETROGENESIS (2-3)** Application of results of experimental rocks at high temperatures and pressures to the origin of igneous rocks. Prerequisites: G.M. 519 or 520; G.M. 550; G.M. 527. *Mr. Burnham*

590. **COLLOQUIUM (1-3)**

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

GEOLOGY (GEOL)

DAVID P. GOLD, *In Charge of Graduate Programs in Geology*
310 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Cuffey, Davis, Gold, Guber, Parizek, Schmalz, Scholten, Spackman, Traverse, Voight, Williams, and Wright.

Graduate Faculty: Associate Members Potter and Slingerland.

Programs are offered in stratigraphy, paleontology, sedimentation, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, engineering geology, marine geology and chemical oceanography, coal geology, coal petrology, and geology of metallic and nonmetallic deposits.

GEOLOGY (GEOL)

†401. **EARTH HISTORY FOR TEACHERS (3)** *Mr. Cuffey*

†402. **FIELD METHODS FOR TEACHERS (3)** *Messrs. Guber, Williams, and Wright*

502. (G.M. 502) **CARBONATES IN THE MARINE ENVIRONMENT (3)** Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach.

503. **PALEONTOLOGY (3-6 per term, maximum of 9)** Morphology of animal groups significant for their fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology. *Mr. Cuffey*

504. **HISTORY AND FOUNDATIONS OF GEOLOGY (2-4)** Theoretical aspects of geology: spatio-temporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought. *Mr. Williams*

506. **SEDIMENTS OF THE WORLD (2-3 per term, maximum of 6)** Evolution of sediments from Archean to recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity. Prerequisites: Min. 512, 514. *Messrs. Scholten and Williams*

509. (Mn.Ec. 509) **GEOLOGY AND ECONOMICS OF THE CONSTRUCTION MATERIALS (3)** Occur-

†This course includes from one to several field trips for which an additional charge will be made to cover transportation.

rence, origin, and marketing of the mineral materials used by the construction industry. Economic and geologic evaluation of actual deposits. *Messrs. Schenck and Wright*

510. (Mn.Ec. 510) GEOLOGY AND ECONOMICS OF THE INDUSTRIAL MINERALS (3) Occurrence, origin, and marketing of the industrial minerals and evaluation of deposits. Chemical and ceramic raw materials emphasized. *Messrs. Schenck and Wright*

511. ORE DEPOSITS: PRINCIPLES (3-6) Geological and geochemical processes controlling ore deposition; genetic classification of ore deposits. Prerequisite: G.Sc. 451.

512. ORE DEPOSITS: TYPES (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511.

524. COAL PETROLOGY (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Mr. Davis*

526. (Biol. 526) PROBLEMS IN PALYNOLOGY (1-6) Systematics: paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history. *Mr. Travers*

540. CHEMICAL OCEANOGRAPHY (3) Chemical reactions in sea water and at the sea floor related to sedimentation and diagenesis. *Mr. Schmalz*

545. GLACIAL GEOLOGY (3) Glaciers: their characteristics, causes, deposits, landforms, effects in periglacial regions. *Mr. Parizek*

546. PRINCIPLES OF PHOTOGEOLOGY (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: G.Sc. 462, 465. *Mr. Gold*

551. DYNAMIC STRUCTURAL GEOLOGY AND GEOTECTONICS (3-6) Phenomena of fracturing, faulting, folding; stress and (finite) strain analysis, physical and analytical models; deformational environments; tectogenesis and orogenesis. *Messrs. Scholten, Voight, and Wright*

555. ADVANCED STRUCTURE AND PETROFABRICS (1-3) Macroscopic and mesoscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks. *Mr. Gold*

562. FLUVIAL GEOMORPHOLOGY (3) Process-oriented analysis of the variables of the fluvial system, emphasizing man's interaction.

571. GEOLOGY FIELD TRIP (1 per year) Field study of regional geologic features with trips in successive years to differing geologic provinces. *Messrs. Scholten and Williams*

581. HABITAT OF OIL (3) Geologic setting of petroleum as determined by basin tectonism, sedimentation, hydraulic and capillary forces, and reservoir textures. *Mr. Scholten*

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

GEOPHYSICS (GPHYS)

SHELTON S. ALEXANDER, *In Charge of Graduate Programs in Geophysics*
404 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Alexander, Graham, Greenfield, Howell, and Lavin.

Graduate Faculty: Associate Member Langston

Students may specialize in seismology, physical properties of rocks, geophysical surveying, geomagnetism, paleomagnetism, geoelectricity, gravity, wave propagation, time-series analysis, space applications of geophysics, tectonics, earth physics, and planetary sciences.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, and earth sciences; and at least 16 credits of intermediate-level work in any one or a combination of these subjects. Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field.

GEOPHYSICS (GPHYS)

400. PHYSICS OF THE EARTH FOR TEACHERS (3)

502. SEISMIC INSTRUMENTS (3) Characteristics and design of seismometers and seismic recorders.

504. COMMUNICATION THEORY FOR GEOPHYSICISTS (3) Basic theory of random processes leading to, and including, optimum filters; geophysical applications to gravity and seismic data analysis.

506. MATERIAL PROPERTIES AND THE CONSTITUTION OF EARTH (3) Application of the properties of materials to the composition and physical state of earth's crust, mantle, and core.

507. SEISMOLOGY (3 per unit)

Unit A. Basic theory; seismic methods for inferring structure of planetary interiors; observational techniques; seismic event location, magnitude, and damage potential.

Unit B. Advanced wave propagation theory; mathematical representation of seismic sources; inversion theory; computational methods.

508. TECTONICS (3) Seminar in the cause and nature of the principal deformations of the earth.

512. GRAVITY AND MAGNETICS (2) Advanced applied methods; application of filter theory and wavenumber domain analysis to data enhancement and interpretation. Prerequisite: G.Sc. 487.

513. ELECTRICAL AND ELECTROMAGNETIC METHODS (2) Advanced applied techniques; theory and procedures for determining subsurface electrical conductivity.

514. SEISMIC METHODS (2) Advanced applied seismic techniques; application of linear system analysis to seismic reflection interpretation problems. Prerequisite: G.Sc. 487.

515. ADVANCES IN EXPLORATION GEOPHYSICS (2) Special topics and new developments in exploration geophysics.

517. COMPUTATIONAL METHODS IN GEOPHYSICS (3) Practical methods of modeling geophysical phenomena for geologic structures; data analysis techniques; systematic inversion of geophysical data; special mathematical approximations.

521. THERMAL STATE OF THE EARTH (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

NOTE: See the Geological Sciences (G.Sc.) listing for 400-level Geophysics courses. Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Mineralogy.

GERMAN (GER)

KEITH O. ANDERSON, *Acting Head of the Department*
S-323 Burrowes Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Senior Members Ebbinghaus, Kopp, and Preisner.

Graduate Faculty: Associate Members Anderson, Browning, Keune, and Ziegler.

There is opportunity for major emphasis upon literature, philology, or the teaching of German. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages.

Students may qualify for the M.A. and M.Ed. degrees either by writing a thesis — which is recommended if a student wishes to be considered for Ph.D. candidacy — or by submitting an essay to the department and taking additional 500-level German courses in lieu of 6 credits of thesis research.

Minimum qualifications for admission include 30 undergraduate credits in German beyond the intermediate level; provision is made, however, for admission with limited deficiencies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

GERMAN (GER)

- 401. ADVANCED COMPOSITION (3)
- 411. THE TEACHING OF GERMAN (3)
- 412. STRUCTURAL ANALYSIS OF MODERN GERMAN (3)
- 430. HISTORY OF THE GERMAN LANGUAGE (3)
- 440. GERMAN STUDIES (3)
- 443. (C.Lit. 443) LITERARY RELATIONS OF GERMANY WITH ENGLAND AND AMERICA (3-9)
- 445. THE VIKINGS (3)
- 450. MEDIEVAL GERMAN LITERATURE I (3)
- 451. MEDIEVAL GERMAN LITERATURE II (3)
- 452. LITERATURE OF THE RENAISSANCE (3)
- 460. LITERATURE OF THE BAROQUE (3)
- 461. LITERATURE OF THE ENLIGHTENMENT (3)
- 462. LITERATURE OF THE LATE EIGHTEENTH CENTURY (3)
- 470. GOETHE (3)
- 471. SCHILLER (3)
- 472. ROMANTICISM (3)
- 480. REALISM (3)
- 481. EARLY TWENTIETH CENTURY (3)
- 482. RECENT GERMAN LITERATURE (3)
- 496. INDEPENDENT STUDIES (1-12)

HIGHER EDUCATION

*1G. ELEMENTARY GERMAN FOR GRADUATE STUDENTS (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. ELEMENTARY GERMAN FOR GRADUATE STUDENTS (3) Continuation of Ger. 1G with opportunity for reading in special fields.

500. BIBLIOGRAPHY AND RESEARCH TECHNIQUES (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language.

520. INTRODUCTION TO MIDDLE HIGH GERMAN (3) Descriptive and historical grammar; readings in simple Middle High German texts.

521. READINGS IN MIDDLE HIGH GERMAN (3) Intensive reading in Middle High German literature, especially of the *Blütezeit*. Prerequisite: Ger. 520.

522. OLD HIGH GERMAN (3) Essentials of the grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D.

523. GOTHIC (3) Introduction to the historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English.

525. OLD ICELANDIC (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.

531. SEMINAR IN MEDIEVAL GERMAN LANGUAGES AND LITERATURES (3-6)

541. SEMINAR IN THE LITERATURE OF THE REFORMATION AND BAROQUE (3-6)

551. SEMINAR IN THE LITERATURE OF THE ENLIGHTENMENT AND THE AGE OF GOETHE AND SCHILLER (3-6)

561. SEMINAR IN POST-IDEALISTIC LITERATURE (3-6)

571. SEMINAR IN MODERN GERMAN LITERATURE (3-6)

581. SEMINAR IN LITERARY GENRES (3-12) Special studies in the German lyric, drama, short story, and novel.

591. SEMINAR IN GERMAN LITERARY CRITICISM (3)

595. INDEPENDENT STUDY (1-9) Selected projects in the study of German literature and philology. Prerequisite: Ger. 500.

597. SPECIAL TOPICS (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

HIGHER EDUCATION (HI ED)

WILLIAM TOOMBS, *In Charge of Graduate Programs in Higher Education*
319 Rackley Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Eddy, Flexner, Ikenberry, Lindsay, Martorana, Mortimer, Sweitzer, and Toombs.

Graduate Faculty: Associate Members Godbey, Moore, and Tierney.

*No graduate credit is given for this course.

The graduate program in the higher education major has as its goal the preparation of individuals who will pursue careers as administrators, faculty, or researchers in the nation's colleges and universities and in a variety of public and private agencies and associations. With emphasis on the systematic study of higher education, the program builds on the scholarly and scientific disciplines offered throughout the University and applies these studies to the professional functions and responsibilities which its graduates will assume.

With mounting awareness of the need for educational reforms and for improved teaching, other departments throughout the University encourage their graduate students to pursue a minor in higher education. The higher education faculty cooperates in this program — which is administered through the students' major departments — by offering a number of courses and seminars designed to promote understanding of post-secondary teaching.

The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Those with a junior-senior average of 3.00, a graduate average of 3.50, and a standardized test score comparable to a 60 on the Miller Analogies Test (MAT) are usually admitted to the D.Ed. program. Applicants with a junior-senior average of 2.70, a graduate average of 3.20, and a MAT score of 50, and with special backgrounds, abilities, and interests will be considered for admission. Some outstanding students may be admitted to the doctoral program with only the baccalaureate degree, but they will earn the master's degree *en route*. For information about special requirements in the higher education major, write: Higher Education, The Pennsylvania State University, 319 Rackley Building, University Park, PA 16802.

HIGHER EDUCATION (HI ED)

460. (Ed.Adm. 460) INTRODUCTION TO ADULT EDUCATION (3)

545. HIGHER EDUCATION IN THE UNITED STATES (2-3) A basis for all courses in higher education. Current issues are analyzed and trends of the future anticipated.

546. COLLEGE TEACHING (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

547. INTERNSHIP IN HIGHER EDUCATION (1-9) Supervised experience in administrative offices, in research, on instructional teams, and in college teaching.

548. CURRICULUMS IN HIGHER EDUCATION (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. COMMUNITY JUNIOR COLLEGE AND THE TECHNICAL INSTITUTE (2-3) Distinctive contributions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration, and finance.

550. THE PROFESSIONS AND THE EDUCATION OF TEACHERS (3) The nature of a profession and dimensions of professional education in the United States are explored. Trends and issues examined.

552. ADMINISTRATION IN HIGHER EDUCATION (2-3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

554. THE HISTORY OF AMERICAN HIGHER EDUCATION (3) An examination of the development of American higher education against the background of influential social, political, economic, and intellectual issues.

555. TOPICAL SEMINARS IN HIGHER EDUCATION (1-6) Current topics including curriculum innovation, contemporary issues in administration, community college governance, governance and politics, finance, planning, and research methodology.

556. COLLEGE STUDENTS (3) Characteristics of college students; changes during college years; educational challenges and responses. Prerequisites: Hi.Ed. 545 or Psy. 426 or I.F.S. 435.

575. (Ed.Adm. 575) ADMINISTRATION OF ADULT EDUCATION (3) The organization of a program of

HISTORY

adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

589. PROBLEMS, PROJECTS, AND AREA STUDIES IN HIGHER EDUCATION (1-6) Independent work in the study of topics in higher education, or development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

HISTORY (HIST)

KENT FORSTER, *Head of the Department*
601 Liberal Arts Tower

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Ameringer, Borza, Brown, Duiker, Eggert, Enteen, Forster, Frantz, Hassler, Maddox, McNall, Murray, Silverman, Sun, and Utechin.

Graduate Faculty: Associate Members Garner, Goldschmidt, Green, Griffith, Harvey, Knight, Linker, Meier, Peattie, Pixton, Spielvogel, Stebbins, and Sweeney.

Graduate work is offered in the following areas of history: ancient, medieval, Europe since 1500, Great Britain and the British Empire, Russia and Eastern Europe, the Middle East, the Far East, the United States, and Latin America. These areas are subdivided into chronological, national, and topical fields.

The candidate for the M.A. or M.Ed. degree selects one of the above areas for the master's examination. Some courses are required in an area in history other than the examination area and in a cognate field or archival option. (The cognate field for an M.Ed. candidate must be in education.) With the consent of the adviser, a master's candidate may substitute additional course work and a paper for a thesis.

The candidate for the doctor's degree must pass examinations in one of the above areas, in a thesis field within that same area, and in one field from a second area. The student must also pass an examination in a single cognate field, or in a study area made up of a number of academic disciplines related to the subject of the thesis. The communication and foreign language requirement for the Ph.D. may be satisfied by a reading knowledge of two foreign languages or one language and work in quantitative techniques. No foreign language is required for the D.Ed. degree, but the candidate must complete a minor in education.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of America from its discovery to the present. Students with a 3.00 junior-senior average and better than a 3.00 average in all undergraduate history courses and appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Each applicant must provide Graduate Record Examination scores and at least three letters of recommendation.

HISTORY (HIST)

401. CLASSICAL CIVILIZATION (3) *Messrs. Borza and Harvey*
402. THE RISE OF THE GREEK POLIS (3) *Mr. Borza*
403. ALEXANDER THE GREAT AND THE HELLENISTIC WORLD (3) *Mr. Borza*
404. THE ROMAN REPUBLIC (3) *Mr. Harvey*
405. THE PAX ROMANA (3) *Mr. Harvey*
406. THE LATER ROMAN EMPIRE (3) *Mr. Harvey*
407. THE MIDDLE AGES FROM CONSTANTINE TO THE CRUSADES (3) *Mr. Sweeney*

408. THE MIDDLE AGES FROM THE CRUSADES TO THE RENAISSANCE (3) *Mr. Sweeney*
410. BYZANTINE CIVILIZATION (3)
411. HISTORY OF ENGLAND IN THE MIDDLE AGES (3) *Mr. Sweeney*
412. INTELLECTUAL HISTORY OF THE MIDDLE AGES (3) *Mr. Sweeney*
414. THE RENAISSANCE (3) *Mr. Spielvogel*
415. THE REFORMATION (3) *Mr. Spielvogel*
417. THE AGE OF ABSOLUTISM (3) *Mr. Green*
418. THE FRENCH REVOLUTION AND THE NAPOLEONIC ERA (3) *Mr. Green*
419. NINETEENTH-CENTURY EUROPE (3) *Mrs. Rosenblatt*
420. RECENT EUROPEAN HISTORY (3) *Mr. Forster*
421. INTELLECTUAL AND CULTURAL HISTORY OF EUROPE, 1600-1800 (3) *Mrs. Knight*
422. INTELLECTUAL AND CULTURAL HISTORY OF EUROPE SINCE 1800 (3) *Mrs. Knight and Mr. Silverman*
423. SOCIAL AND ECONOMIC HISTORY OF EUROPE SINCE 1750 (3) *Mr. Silverman*
425. DIPLOMATIC HISTORY OF EUROPE SINCE 1870 (3) *Mr. Forster*
427. GERMANY SINCE 1640 (3) *Mr. Silverman*
428. FRANCE SINCE 1610 (3) *Mrs. Knight*
430. EASTERN EUROPE IN MODERN TIMES (3) *Mr. Enteen*
432. HISTORY OF RUSSIA TO 1700 (3) *Mr. Utechin*
433. IMPERIAL RUSSIA, 1700-1917 (3) *Mr. Utechin*
434. HISTORY OF THE SOVIET UNION (3) *Mr. Enteen*
436. BRITAIN UNDER THE TUDORS AND STUARTS, 1485-1688 (3) *Mr. Linker*
437. GREAT BRITAIN, 1688-1832 (3) *Mr. Linker*
438. GREAT BRITAIN SINCE 1832 (3) *Mr. Linker*
440. COLONIAL AMERICA TO 1753 (3) *Mr. Frantz*
441. REVOLUTIONARY AMERICA, 1753-1783 (3) *Mr. Frantz*
442. THE FORMATIVE PERIOD OF AMERICAN HISTORY (3) *Mr. Brown*
443. THE MIDDLE PERIOD OF AMERICAN HISTORY (3) *Mr. McNall*
444. THE UNITED STATES IN CIVIL WAR AND RECONSTRUCTION (3) *Mr. Hassler*
445. THE EMERGENCE OF MODERN AMERICA (3) *Mr. Eggert*
446. AMERICA BETWEEN THE WARS (3) *Mr. Murray*
447. RECENT AMERICAN HISTORY (3) *Mr. Murray*
449. CONSTITUTIONAL HISTORY OF THE UNITED STATES TO 1877 (3) *Mr. Stebbins*
450. CONSTITUTIONAL HISTORY OF THE UNITED STATES SINCE 1877 (3) *Mr. Stebbins*
451. HISTORY OF AMERICAN POLITICAL PARTIES (3)
452. DIPLOMATIC HISTORY OF THE UNITED STATES TO 1900 (3) *Mr. Maddox*
453. THE DIPLOMATIC HISTORY OF THE UNITED STATES SINCE 1900 (3) *Mr. Maddox*
454. AMERICAN MILITARY HISTORY (3) *Mr. Hassler*
455. AMERICAN ECONOMIC HISTORY IN THE AGRICULTURAL ERA (3) *Mr. McNall*
456. AMERICAN ECONOMIC HISTORY IN THE INDUSTRIAL ERA (3) *Mr. Eggert*
457. HISTORY OF THE AMERICAN FRONTIER (3) *Mr. McNall*
458. (L.S. 458) HISTORY OF AMERICAN ORGANIZED LABOR SINCE 1877 (3) *Mr. Eggert*
459. SOCIAL AND CULTURAL HISTORY OF THE UNITED STATES SINCE 1783 (3) *Mr. Brown*
460. UNITED STATES FOREIGN INTELLIGENCE (3) *Mr. Ameringer*
464. SPANISH CONQUEST OF THE NEW WORLD (3) *Mr. Garner*
465. LATIN AMERICAN INDEPENDENCE MOVEMENTS (3) *Mr. Garner*
467. LATIN AMERICA AND THE UNITED STATES (3) *Mr. Ameringer*
468. MEXICO AND THE CARIBBEAN NATIONS IN THE TWENTIETH CENTURY (3) *Mr. Ameringer*
471. HISTORY OF ARABIC CIVILIZATION, 600-1258 (3) *Mr. Goldschmidt*
472. THE OTTOMAN EMPIRE AND OTHER MUSLIM STATES (3) *Mr. Goldschmidt*
473. THE CONTEMPORARY MIDDLE EAST (3) *Mr. Goldschmidt*
477. HISTORY OF CENTRAL AND EAST AFRICA (3) *Mr. Griffith*
478. HISTORY OF WEST AFRICA (3) *Mr. Griffith*
480. THE HISTORY OF TRADITIONAL JAPAN (3) *Mr. Peattie*
481. THE HISTORY OF MODERN JAPAN (3) *Mr. Peattie*
483. TRADITIONAL CHINA TO 1800 (3) *Mrs. Sun*

485. NINETEENTH-CENTURY CHINA (3) *Mrs. Sun*
486. TWENTIETH-CENTURY CHINA (3) *Mr. Duiker*
488. TWENTIETH-CENTURY SOUTHEAST ASIA (3) *Mr. Duiker*
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
501. HISTORICAL METHOD (3) *Messrs. Meier and Utechin*
502. HISTORIOGRAPHY (3) *Messrs. Borza and Meier*
503. STUDIES IN GREEK HISTORY (3-6) *Mr. Borza*
504. STUDIES IN ROMAN HISTORY (3-6) *Mr. Harvey*
509. MEDIEVAL CIVILIZATION (3-9) *Mr. Sweeney*
511. STUDIES IN MEDIEVAL ENGLISH HISTORY (3-6) A seminar in the political, economic, and cultural history of England in the Middle Ages.
515. THE AGE OF THE REFORMATION (3-6) *Mr. Spielvogel*
517. STUDIES IN EUROPEAN HISTORY, 1600-1750 (3-6) *Mrs. Knight and Mr. Green*
519. STUDIES IN EUROPEAN HISTORY, 1750-1900 (3-6) *Mrs. Knight and Mr. Silverman*
520. STUDIES IN TWENTIETH-CENTURY EUROPE (3-6) *Messrs. Forster and Silverman*
530. SEMINAR IN EASTERN EUROPEAN HISTORY (3-6) *Messrs. Enteen and Utechin*
533. STUDIES IN RUSSIAN AND SOVIET HISTORY (3-6) *Messrs. Enteen and Utechin*
537. STUDIES IN BRITISH HISTORY (3-6) *Mr. Linker*
540. COLONIAL AND REVOLUTIONARY AMERICA (3-6) *Mr. Frantz*
543. THE UNITED STATES, 1783-1860 (3-6) *Mr. McNall*
544. THE UNITED STATES, 1860-1877 (3-6) *Mr. Hassler*
545. THE UNITED STATES, 1877-1919 (3-6) *Mr. Eggert*
546. THE UNITED STATES SINCE 1919 (3-6) *Mr. Murray*
550. STUDIES IN CONSTITUTIONAL HISTORY (3-9) A graduate seminar examining constitutional developments in their historical context through readings, class discussions and research papers. *Mr. Stebbins*
553. DIPLOMATIC HISTORY OF THE UNITED STATES (3-6) *Mr. Maddox*
555. ECONOMIC HISTORY OF THE UNITED STATES (3-6) *Messrs. Eggert and McNall*
559. CULTURAL HISTORY OF THE UNITED STATES (3-6) *Mr. Brown*
560. STUDIES IN PENNSYLVANIA HISTORY (3-6) *Mr. Frantz*
568. STUDIES IN THE HISTORY OF THE CARIBBEAN AREA (3 per term, maximum of 6) *Mr. Ameringer*
569. SEMINAR IN LATIN-AMERICAN HISTORY (3-6) *Mr. Ameringer*
573. STUDIES IN MIDDLE EASTERN HISTORY (3-6) *Mr. Goldschmidt*
583. STUDIES IN ASIAN HISTORY (3-9) *Mrs. Sun and Messrs. Duiker and Peattie*
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

HOME ECONOMICS EDUCATION (HE ED)

TWYLA M. SHEAR, *In Charge of Graduate Programs in Home Economics Education*
212 Rackley Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members East, Ray, Shear, and Weis.

Graduate Faculty: Associate Members Murray and Thal.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

Students who have majored as undergraduates in some aspect of home economics and who have achieved a grade-point average of at least 2.50 in their junior and senior years will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Students wishing to be admitted to the doctoral programs must have completed a master's degree and will be admitted subject to limitations of departmental facilities. There is no foreign language requirement for degrees in the program.

HOME ECONOMICS EDUCATION (HE ED)

- 406v. AUDIO-VISUAL METHODS FOR HOME ECONOMICS (1-4)
 - 410v. SUPERVISION OF STUDENT TEACHERS (1-3)
 - 427v. TEACHING HOME ECONOMICS (3)
 - 466v. STUDENT TEACHING (9)
 - 477v. CURRICULUM DEVELOPMENT FOR HOME ECONOMICS IN SECONDARY SCHOOLS (3)
 - 478v. APPRAISING STUDENT PROGRESS IN HOME ECONOMICS (3)
 - 480v. PROBLEMS IN TEACHING HOME ECONOMICS (3-6)
 - 481v. EMPLOYMENT PREPARATION PROGRAMS IN VOCATIONAL HOME ECONOMICS (3)
 - 482v. POSTSECONDARY, ADULT, AND CONTINUING EDUCATION PROGRAMS IN HOME ECONOMICS (3)
 - 496v. INDEPENDENT STUDIES (1-12)
 - 497v. SPECIAL TOPICS (1-6)
- 502, 502v. HOME ECONOMICS INSTRUCTION AT THE COLLEGE LEVEL (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers.
- 503, 503v. HOME ECONOMICS TEACHER EDUCATION (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics.
- 504, 504v. EDUCATIONAL ISSUES AND HOME ECONOMICS (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience.
- 510, 510v. EDUCATIONAL LEADERSHIP IN HOME ECONOMICS (2-6) Principles of educational leadership for home economists preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education major and two years' teaching experience in home economics.
- 511, 511v. INTERNSHIP IN HOME ECONOMICS SUPERVISION AND ADMINISTRATION (2-8) Opportunity to understudy an educational leader in student teacher supervision, state supervision, department or college administration, or regional consultation. Prerequisite: H.E.Ed. 510.
- 518, 518v. EVALUATION OF HOME ECONOMICS PROGRAMS (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision.

521, 521v. HOME ECONOMICS EDUCATION SEMINAR (2-3) Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.

530, 530v. PROBLEMS IN HOME ECONOMICS EDUCATION (1-6 per term) Individual investigation of problems related to the teaching, supervision, or administration of home economics education.

577v. CURRICULA IN HOME ECONOMICS (3) Development of curricula in home economics. Prerequisite: H.E.Ed. 477v.

602v. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

HORTICULTURE (HORT)

ROGER W. HEPLER, *Head of the Department*
103 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Beelman, Bergman, Craig, Garwood, Grun, Martsoff, McArdle, Ritter, Shannon, Smith, Stinson, Tukey, and White.

Graduate Faculty: Associate Members Cole, Daniels, Haramaki, Hepler, Heuser, Holcomb, Kuhn, Mastalerz, Pfahl, and Wallner.

Students may specialize in several phases of production, plant genetics and breeding, soils and plant nutrition, horticultural physiology, post-harvest physiology, plant propagation, and microclimatology. Students wishing additional credits in the commodity areas of floriculture, olericulture, ornamental horticulture, and pomology, or in the areas of specialization listed above, should register for Hort. 501.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one of four options: (1) comprehensive competence in one language, (2) reading examination or two-course sequence in two languages, (3) reading examination or two-course sequence in one language plus 6 credits in other communications skills, or (4) 6 credits in each of two areas of communication skills.

Prerequisites for admission vary according to the area of specialization, but basic courses in physical sciences, mathematics, biological sciences, communication skills, and social sciences and humanities are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

HORTICULTURE (HORT)

- 401. PLANT PROPAGATION (3) *Mr. Haramaki*
- 402. PLANT NUTRITION (3) *Mr. Bergman*
- 403. HORTICULTURE PLANTS AND THEIR ENVIRONMENT (3) *Mr. Mastalerz*
- 404. ADVANCED HORTICULTURE CROP SCIENCE (3-12)
- 405. SENIOR SEMINAR IN HORTICULTURE (1-2)
- 407. PLANT BREEDING (3) *Mr. Garwood*
- 412. POST-HARVEST PHYSIOLOGY (3) *Mr. Wallner*
- 444. ADVANCED PLANT BREEDING (3-6) *Mr. Craig*
- 451. FLOWER STORE MANAGEMENT (4) *Mr. Pfahl*
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501. EXPERIMENTAL PROBLEMS IN HORTICULTURAL SCIENCE (1-12) Investigation of problems in floriculture, olericulture, ornamental horticulture, plant breeding, nutrition, or pomology.

506. NUTRITION OF HORTICULTURAL CROPS (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Mr. Smith*
512. PRINCIPLES OF FRUIT AND VEGETABLE STORAGE (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application. *Mr. Wallner*
514. PROPAGATION AND IMPROVEMENT OF HORTICULTURE PLANTS (1-6) Biological factors affecting sexual and asexual propagation of plants; techniques in plant improvement; maintenance of propagation material. *Mr. Heuser*
517. HORTICULTURE SEMINAR (1 per term) Review of current research publications in horticulture. Each student presents one or more reviews of assigned topics.
520. GENETICS AND BREEDING SEMINAR (1 per term) Review of research and literature in genetics and breeding of horticultural crops.
524. EXPERIMENTAL PROCEDURES IN HORTICULTURAL RESEARCH (3) *Mr. Craig*
528. PROBLEMS IN FRUIT AND VEGETABLE PROCESSING (2-12) *Mr. McArdle*

HUMAN DEVELOPMENT AND FAMILY STUDIES (HD FS)

JOHN R. NESSELROADE, *In Charge of Graduate Programs in Human Development and Family Studies*
S-106 Henderson Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Baltes, Britton, Burgess, Danish, D'Augelli, de Lissoy, Ford, Gottesman, B. Guernsey, L. Guernsey, Gunter, Hultsch, Huston, Knoll, Lerner, Liben, Nesselroade, Peters, Spanier, Taylor, Urban, Vondracek, and Walcher.

Graduate Faculty: Associate Members Deutsch, Goldberg, Hefferan, Lyness, Nelson, Nowak, Schilmoeller, Seward, Smyer, Szinovacz, Treat, and Willis.

This interdisciplinary program is one of the graduate programs of the College of Human Development. It is administered through the Division of Individual and Family Studies. The program focuses on the developmental study of individuals, small groups, and families for the purposes of expanding basic knowledge and professional application. The perspective encompasses the individual life span, from infancy and childhood through later maturity and old age, as well as the full cycle of the family. For both individual and family, the perspective includes variations in functioning patterns and the use of resources; the impact of diverse social, economic, and cultural contexts upon behavior; conditions which promote adaptive individual, group, and family development; and the creation of techniques of accomplishing human development. Emphasis is upon the integration of knowledge from various fields for understanding and developing skills for careers in research and scholarship, teaching, program planning and evaluation, and other professional services. The faculty includes persons primarily in the behavioral and social sciences particularly committed to research and application in these multi- and interdisciplinary areas.

The student's program is expected to include work assuring both breadth in the major field and depth within one of three program areas: family development, human development intervention, or individual development. Further specialization is possible in adult development and aging, child and adolescent development, early childhood services, interpersonal relations, family economics and management, and family relationships.

Infant and early childhood laboratories are operated as part of the teaching and research program. Each unit has observational facilities and rooms for study of individual and group behavior of children and adults. The Individual and Family Consultation Center provides facilities for the development and evaluation of educational programs for remediation of individual and family problems by professional and paraprofessional persons. The Institute for the Study of Human Development, the Center for Human Services Development, the Gerontology Center, the Center for Youth Study and Social Policy,

the Pennsylvania Field Research Laboratory, and a simulation laboratory provide opportunities for participation in research and evaluation projects. Additional resources are available in other parts of the University.

A research and evaluation methodology core, required of all students, may be satisfied by selections from a variety of courses across the campus. Use may be made also of courses in other parts of the college and University to build substantive competence in the program. The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages. A minor or general studies group outside the major is required of all doctoral students.

Entering students should have at least 6 credits in the biological and physical sciences; 12 in the social sciences and, depending upon proposed area of emphasis, basic courses in sociology, psychology, and economics; and 6 in developmental and family studies. Students not meeting these requirements may be admitted with limited deficiencies to be made up concurrently with their graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission, which, with rare exception, will be for fall term only. Early application is required, and a special application to HDFS must be completed; additional information may be obtained from the professor in charge. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. The Graduate Record Examination is required of all applicants.

INDIVIDUAL AND FAMILY STUDIES (I F S)

- 410. COMMUNITIES AND FAMILIES (3)
- 411. THE HELPING RELATIONSHIP (3)
- 412. ADULT-CHILD RELATIONSHIPS (3)
- 413. DYSFUNCTIONS IN THE DEVELOPMENTAL PROCESS (3)
- 414. RESOLVING INDIVIDUAL AND FAMILY PROBLEMS (3)
- 415. CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS FOR SECONDARY SCHOOLS (3)
- 416. (C.S. 416) CONSUMER ROLE OF FAMILY (3)
- 418. FAMILY RELATIONSHIPS (3)
- 419. PROBLEMS OF FAMILY FINANCIAL MANAGEMENT (3)
- 420. PROBLEMS IN THE ANALYSIS OF INDIVIDUAL DEVELOPMENT (3-9)
- 424. ECONOMIC CONDITIONS IN RELATION TO THE FAMILY (3)
- 427. CONCEPTIONS IN DEVELOPMENT (3)
- 428. INFANT DEVELOPMENT (3)
- 429. ADVANCED CHILD DEVELOPMENT (3)
- 430. PRACTICUM IN PRESCHOOL GROUPS (1-6)
- 432. DEVELOPMENTAL PROBLEMS OF NORMAL CHILDREN (3)
- 435. DEVELOPMENTAL TRANSITION TO ADULTHOOD (3)
- 439. FAMILY RESOURCE MANAGEMENT (2)
- 441. ORGANIZATION PLANNING FOR PRESCHOOL PROGRAMS (3)
- 442. HOME MANAGEMENT EXPERIENCE (3)
- 445. (Psy. 445) DEVELOPMENT THROUGHOUT ADULTHOOD (3)
- 470. (Psy. 470) SOCIAL LEARNING FOUNDATIONS OF BEHAVIOR CHANGE (3)
- 474. (C.&S. 474) EDUCATIONAL FOCUS ON DEVELOPMENTAL CHILD CARE (3)
- 477. ANALYSIS OF FAMILY PROBLEMS (2-9)
- 481. DEVELOPMENTAL PROGRAMMING FOR PRESCHOOL CHILDREN (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

500. NONTHESIS RESEARCH (1-9)

501. SEMINAR: ISSUES IN THE STUDY OF INDIVIDUAL AND FAMILY DEVELOPMENT (1-3) Reading, reports, and discussion of conceptual frameworks for multidisciplinary and developmental study of individuals and families.

504. **PRACTICUM IN PROGRAM DEVELOPMENT FOR PRESCHOOL CHILDREN (2-6)** Investigation, analysis, and report on the design, development, and evaluation of a selected program for preschool children. Prerequisites: 6 credits of individual development and I.F.S. 430, 441.
506. **PROJECTS IN DESIGN AND EVALUATION OF PROGRAMS FOR PRESCHOOL CHILDREN (2-4)** Individual projects in the design, implementation, and evaluation of different teaching approaches with varying groups of children. Prerequisites: I.F.S. 504 and 3 credits in research methods.
508. **PARENTAL EDUCATION (1-6)** Implementing educational and preventive programs for parents; discussion and evaluation of theory and techniques.
511. **MODIFYING CONJUGAL LIFE (1-9)** Conceptual foundations, research procedures, and practicum experience in teaching effective communication and problem-solving skills in the marriage relationship. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.
512. **FILIAL RELATIONSHIP MODIFICATION (1-9)** Theory, research, and practicum in teaching parents to resolve developmental problems in their own children. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.
513. **GROUP PROCEDURES IN INDIVIDUAL DEVELOPMENT (1-6)** Theory, research, and practicum experience in the use of group methods for promoting individual development in different age groups. Prerequisites: I.F.S. 411 and research methods or statistics.
515. **TEACHING INDIVIDUAL DEVELOPMENT AND FAMILY STUDIES (1-6)** Objectives, techniques, materials, and evaluation in teaching at the secondary and college level, and in adult and public education programs.
520. **SEMINAR IN PRENATAL AND INFANT DEVELOPMENT (1-6)** Prenatal and infant development, with emphasis on multiple determinants of early development and their relationship to later behavior. Prerequisites: 6 graduate credits in individual development, psychology, or biological science and 3 credits in statistics.
522. **SEMINAR IN DYSFUNCTION PROCESSES IN INDIVIDUAL DEVELOPMENT (1-6)** Multiple processes involved in dysfunctional development in the individual across the life-span. Prerequisite: I.F.S. 413.
524. **THEORETIC ANALYSIS OF FAMILY ECONOMIC AND MANAGERIAL BEHAVIOR (3)** Conceptual approaches and major contributions to the study of the organizational, managerial, and economic functions of the family. Prerequisite: I.F.S. 418 or 424 or 477.
525. **THEORIES OF FAMILY RELATIONSHIPS (3)** Assessment of the utility of major theories for empirical analysis of interpersonal interactions among family members. Prerequisite: I.F.S. 418.
529. **(Psy. 529) SEMINAR IN CHILD DEVELOPMENT (1-6)** Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.
530. **INDEPENDENT STUDY IN INDIVIDUAL AND FAMILY STUDIES (1-9)** Problems involving individual study. Prerequisite: instructor's approval of proposed study.
532. **FIELD PROJECTS IN INDIVIDUAL AND FAMILY STUDIES (1-9)** Supervised research or internship in human services program. Prerequisite: instructor's approval of proposed project.
536. **(Psy. 536) RESEARCH METHODS IN DEVELOPMENTAL PROCESSES (3)** Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology and a course in statistics.
539. **SEMINAR IN ADOLESCENT DEVELOPMENT (1-6)** Cultural, psychological, and biological aspects of the developmental transition to adulthood. Prerequisites: 6 credits in individual development or psychology and 3 credits in sociology and statistics.
543. **MODIFICATION OF FAMILY MANAGERIAL PRACTICES (1-3)** Conceptual issues, research, and practicum experience in assisting families in the solution of financial and managerial problems.
544. **SEMINAR IN DYSFUNCTIONAL PATTERNS IN FAMILY ORGANIZATION (1-6)** Processes of

familial dysfunction and disorganization and their explanation in economic, social-psychological, and managerial terms. Prerequisite: I.F.S. 418 or 424 or Soc. 430.

545. FAMILIES AND SOCIOECONOMIC SYSTEMS (1-6) Functional interrelationships between families and social and economic systems. Prerequisites: I.F.S. 418, 424.

546. SEMINAR IN FAMILY RELATIONSHIPS (1-9) Interpersonal interaction within family systems throughout the life cycle. Prerequisite: I.F.S. 418.

549. (Psy. 549) DEVELOPMENTAL THEORY (3) Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.

550. SEMINAR IN FAMILY ECONOMICS AND MANAGEMENT (1-6) Recent developments in the study of family economic and managerial practices.

579. SEMINAR IN ADULT DEVELOPMENT AND AGING (1-9) A seminar dealing with specific topics concerning adult development and aging. Prerequisites: I.F.S. 445 and statistics.

590. COLLOQUIUM (1-3)

597. SPECIAL TOPICS (1-6)

HUMANITIES (HUMAN)

ROBERT J. GRAHAM, *Program Head, Humanities*
The Capitol Campus, Middletown, PA 17057

Degree Conferred: M.A.

Graduate Faculty: Senior Members Dordevic, Richman, Tischler, and M. Wolf.

Graduate Faculty: Associate Members R. Graham, T. Graham, Haber, and Mahar.

Defining humanities as the study of men and societies through examinations of their arts, this program aims at developing skills for the interdisciplinary study of art, music, literature, drama, and dance. Entering students are expected to have studied in at least two of these areas. Exceptions may be made for students with special backgrounds and abilities who are committed to attaining competence in a second area. A committee will meet with each student to determine individual needs and arrange a program designed to develop essential skills for the analysis of works; for the classification of works into genres, periods, and schools; for the evaluation of works by applications of appropriate criteria; for the definition of individual, school, and period styles; and for the perception of relationships between various styles, media, periods, and cultures. For students who plan to teach in a junior college, there is also provision for an internship option.

A series of six 500-level courses is designed to help a student develop a number of the program skills. In addition, the adviser may suggest enrollment in certain 400-level courses or in independent studies with qualified faculty. The degree program does, however, require completion of 18 credits at the 500 level.

To qualify for the M.A. in humanities, the student must demonstrate competence in applying the methods of humanistic inquiry to a relevant subject area. Course work and independent study will help in the development of the appropriate skills and the acquisition of necessary knowledge, but the degree is not awarded in recognition of a set total number of course credits having been compiled; the degree testifies that the recipient has cultivated the necessary skills of analysis and synthesis and has successfully completed a scholarly or creative master's production.

Ordinarily, a full-time student can expect to complete the program in three or four terms, a part-time student in six to nine terms.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that

are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is available only at the Capitol Campus.

HUMANITIES (HUMAN)

500. RESEARCH METHODS (3) Study of the methods and materials of scholarship, compilation of bibliographies, writing of scholarly papers, and proper documentation.

502. PERENNIAL ISSUES IN THE HUMANITIES (3) Recurrent issues viewed in terms of their significance to the artist, historian, and the philosopher.

503. INTERRELATIONS IN THE HUMANITIES (3) An interdisciplinary study of the interdependence of aesthetic values in various art forms as they exist in cultural settings. Prerequisite: Human. 500.

520. STUDIES IN STYLE (3) Study of prominent stylistic patterns, evaluating the essence of a style, and the varied responses of the artist and philosopher within a pattern.

525. STUDIES IN AESTHETICS (3) Study of certain techniques in the arts that presuppose certain aesthetic concepts and certain ideas that demand parallel form.

580. MASTER'S PRODUCTION (1-6) An original scholarly master's paper or creative production initiated by the student, supervised by an appropriate professor, and judged by a committee.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

EDUCATION (ED)

505. CURRICULUM FOUNDATIONS (3) Study of the philosophical, cultural, social, and human developmental sources and implications of the school curriculum.

506. CURRICULUM DEVELOPMENT (3) Examination of theory, issues, organization, and local school problems of curriculum development.

520. SEMINAR IN JUNIOR COLLEGE TEACHING (3) The history of the two-year college, responsibilities of the teacher in the college organization, and methods of teaching.

541. THE ROLE OF THE COOPERATING TEACHER (3) A study of the responsibilities of classroom teachers who cooperate with teacher-preparation institutions. Prerequisite: teaching experience.

550. INTERNSHIP IN JUNIOR COLLEGE (3) Teaching humanities courses in a two-year college under a master teacher, who will direct, criticize, and evaluate the intern.

551. PROBLEMS IN TEACHING READING (3) A research-centered course in teaching reading. Prerequisite: Ed. 322, 451, 471, or 472.

552. PROBLEMS IN TEACHING LANGUAGE ARTS (3) A research-centered course in teaching language arts. Prerequisite: Ed. 416 or 452.

553. PROBLEMS IN TEACHING SOCIAL STUDIES (3) A research-centered course in teaching social studies. Prerequisite: Ed. 415 or 453.

554. PROBLEMS IN TEACHING SCIENCE (3) A research-centered course in teaching elementary science. Prerequisite: Sc. 454.

555. PROBLEMS IN TEACHING MATHEMATICS (3) A research-centered course in teaching mathematics. Prerequisite: Ed. 455.

560. CLASSROOM MANAGEMENT (3) Analysis of teaching styles, classroom behavior and interaction, organization and correlation of classroom activities and subject areas. (Requires practical application in an actual teaching situation.)

561. PSYCHOLOGY OF READING (3) Examination of the theoretical bases for reading which have direct practical implication for teaching reading. Prerequisites: Ed. 314, 451.

562. **LEARNING PROBLEMS IN A SCHOOL SETTING (3)** Investigation of surface behaviors and sources of stress in schools which hinder learning, and procedures for overcoming problems.
563. **ADVANCED METHODS IN TEACHING READING (3)** Advanced development of diagnostic and instructional techniques for teaching reading, with emphasis on individual and small group instruction. Prerequisite: Ed. 451.
564. **READING CLINIC (3-6)** A practicum course in which students display their competencies in working with children possessing reading problems. Prerequisite: Ed. 563.
571. **GREAT TEACHERS (3)** Study of one or more great teachers, e.g., Socrates, Comenius, Locke, Rousseau, Pestalozzi, Herbart, Froebel, Dewey, Kilpatrick.
572. **COMPARATIVE EDUCATION: WORLD PERSPECTIVES (3)** An evaluative comparison of American education with Western and non-Western educational systems.
585. **MASTER'S PRACTICUM (1-6)** The planning, implementation, and evaluation of an educational innovation in a classroom, or related learning activity.
586. **EDUCATIONAL RESEARCH DESIGNS (3)** Identification of research designs appropriate to educational field and laboratory investigations and the development of a master's paper proposal. Prerequisite: 15 credits of graduate study.
587. **MASTER'S PAPER (1-6)** Development of an original master's paper or creative production by the student, supervised by appropriate faculty and judged by a committee. Prerequisite: consent of adviser.
589. **PROBLEMS IN URBAN EDUCATION (4)** Independent study of selected topics related to urban education.
590. **COLLOQUIUM (1-3)**
591. **EDUCATION SEMINAR (1-6)** Seminars in important, and often controversial, topics in education.
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

INDUSTRIAL ENGINEERING (I E)

BENJAMIN W. NIEBEL, *Head of the Department of Industrial and Management Systems Engineering*
207 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Draper, Ham, Ignizio, Niebel, Raphael, and Rosenshine.

Graduate Faculty: Associate Members Callahan, Creese, Ensore, Freark, Guild, Keith, Kozik, Olsen, Thuering, and Zindler.

Graduate study and research are conducted in operations research-management science, production engineering, process design, systems engineering, and human engineering.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of one foreign language (Russian, German, French, or Japanese).

Graduates in industrial engineering, other engineering curriculums, and mathematics who present a 2.50 junior-senior average will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

INDUSTRIAL ENGINEERING (I E)

- 400. ENGINEERING FOR PRODUCTION (3)
- 402. ENGINEERING ECONOMY (3)
- 403. ENGINEERING ECONOMY AND STATISTICS (3)
- 404. MANAGEMENT SCIENCE (3)
- 405. LINEAR PROGRAMMING (3)
- 406. DESIGN OF PRODUCTION AND DISTRIBUTION SYSTEMS (3)
- 407. QUANTITATIVE METHODS FOR OPERATIONS RESEARCH (3)
- 408. HUMAN FACTORS ENGINEERING (3)
- 414. MATERIALS JOINING PROCESSES AND PRINCIPLES (3)
- 423. QUALITY CONTROL (3)
- 424. PROBLEMS IN PERSONNEL MANAGEMENT (3)
- 425. INTRODUCTION TO OPERATIONS RESEARCH (3)
- 426. INDUSTRIAL AUTOMATION (3)
- 427. SOLIDIFICATION OF CASTINGS (3)
- 428. FOUNDRY ENGINEERING (3)
- 432. INTRODUCTION TO RELIABILITY ENGINEERING (1-3)
- 438. METAL CUTTING PRINCIPLES AND PRACTICE (3)
- 439. ENGINEERING SYSTEMS OPTIMIZATION (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. MANUFACTURING METHODS (2-8) Special projects including investigation, experimentation, design, and research of one or more special types of manufacture.
- 502. MANAGEMENT METHODS (3-6) Scientific management, including management controls and mathematical programming; research on special problems.
- 503. INDUSTRIAL RELATIONS (1-6) Study of human problems related to labor unions, hierarchy, specialization; analysis of organizational structure, policies, decision criteria, and communication systems.
- 506. ADVANCED WORK DESIGN AND MEASUREMENT (3-9) Methods of research in motion and time study; critical analysis of current literature.
- 507. OPERATIONS RESEARCH: SCHEDULING MODELS (3) Scheduling models with simultaneous job arrival and probabilistic job arrival, network scheduling and scheduling simulation techniques. Prerequisite: I.E. 425.
- 508. OPERATIONS RESEARCH: INVENTORY MODELS (3) A study of inventory theory, deterministic models, probabilistic models, multiproduct models in both the single and multiperiod modes. Prerequisite: I.E. 425.
- 509. OPERATIONS RESEARCH: WAITING LINE MODELS (3) Waiting line models including models with infinite queues, finite queues, single and multiple servers under various priorities and disciplines. Prerequisite: I.E. 425.
- 510. MATHEMATICAL PROGRAMMING (3) Study of advanced topics in linear programming including duality, decomposition, sensitivity analysis, parametric programming, and selected topics in mathematical programming. Prerequisite: I.E. 405.
- 511. EXPERIMENTAL DESIGN IN ENGINEERING (3) Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisite: I.E. 323.
- 512. GRAPH THEORY AND NETWORKS IN MANAGEMENT SCIENCE (3) Prerequisite: I.E. 425.
- 513. REAL TIME DATA PROCESSING FOR ENGINEERING SYSTEMS (3) Random access computers and communication components for real time systems; engineering systems simulation on digital computers. Prerequisite: Cmp.Sc. 102 or 410.

515. **COMPLEX LINEAR FLOW MODELS (3)** Application of complex linear flow models in engineering and management science, including static and dynamic system simulations. Prerequisite: I.E. 405.
516. **APPLIED STOCHASTIC PROCESSES I (3)** Prerequisite: Stat. (Math.) 427.
517. **APPLIED STOCHASTIC PROCESSES II (3)** Prerequisite: I.E. 516.
518. **PLASTIC DEFORMATION PROCESSES (3)** Study of the principles, theories, technology, design, and application of plastic deformation processes to shape metals. Prerequisite: undergraduate engineering degree.
519. **DYNAMIC PROGRAMMING (3)** Study of the concepts underlying model-building and optimization of dynamic systems with application to engineering, economic, and environmental systems. Prerequisites: I.E. 405 or Q.B.A. 451; Stat. 418.
520. **GOAL PROGRAMMING (3)** Study of concepts and methods in analysis of systems involving multiple objectives with applications to engineering, economic and environmental systems. Prerequisite: I.E. 405 or Q.B.A. 451.
528. **METAL CUTTING THEORY (3)** Study of the theory of metal cutting, contemporary and future problems of metal removal processes; critical analysis of current literature. Prerequisite: I.E. 438.
538. **EXPERIMENTAL INVESTIGATIONS IN MATERIALS PROCESSING (3)** Experimental investigation on selected subjects in processing involving instrumentation, methods, and analysis. Prerequisite: I.E. 528.
596. **INDIVIDUAL STUDIES (1-6)**

JOURNALISM (JOURN)

DANIEL W. PFAFF, *In Charge of the Graduate Program in Journalism*
218 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty: Senior Member Barnes.

Graduate Faculty: Associate Members Dulaney, Froke, Goodwin, Norris, Pfaff, Smith, Tenney, and Zanot.

The program is flexible so as to meet the needs of students with various undergraduate or professional backgrounds. Candidates may select a 30-credit thesis program or a 36-credit nonthesis program. Generally, the thesis program is for those with an undergraduate major or professional experience in journalism or communications, or for those who plan to pursue a doctoral degree. Its purpose is to provide an understanding of the structure and functions of communications in modern societies, and a strong minor in an appropriate field is normally required. The nonthesis program is usually selected by candidates with undergraduate majors in the humanities or social sciences and who now wish academic training for a journalistic career. All candidates must take at least one course dealing with research in communications problems. Other requirements are tailored to the individual's background, interests, and goals.

Students with a 3.00 junior-senior average and appropriate course backgrounds will be considered for admission. Those with lower averages will be considered if their achievements since graduation recommend them. Applicants must submit Graduate Record Examination scores (verbal and quantitative) and an autobiographical statement of about 1,000 words indicating career objectives and type of program preferred.

JOURNALISM (JOURN)

401. **MASS MEDIA IN HISTORY (3)**
403. **LAW OF MASS COMMUNICATIONS (3)**
405. **POLITICAL ECONOMY OF COMMUNICATIONS (3)**

407. ADVERTISING IN CONTEMPORARY SOCIETY (3)
 409. CRITICS AND ETHICS OF THE MASS MEDIA (3)
 411. CULTURAL ASPECTS OF THE MASS MEDIA (3)
 413. THE MASS MEDIA AND THE PUBLIC (3)
 415. CURRENT ISSUES IN ADVERTISING (3)
 416. (Engl. 416) SCIENCE WRITING (3-6)
 417. ADVERTISING AND CONSUMERISM (3)
 419. (Sp.Com. 419) COMPARATIVE BROADCASTING SYSTEMS (3)
 421. PUBLIC AFFAIRS REPORTING (3)
 423. REPORTING OF CONTEMPORARY ISSUES (3)
 425. NEWS EDITING AND EVALUATION (3)
 427. MAGAZINE JOURNALISM (3)
 429. EDITORIAL INTERPRETATION (3)
 436. (Soc. 436) SOCIOLOGY OF OPINION FORMATION (3)
 441. ADVERTISING COMMUNICATIONS PROBLEMS (3)
 443. ADVERTISING MEDIA PLANNING (3)
 445. ADVERTISING CAMPAIGNS (3)
 451. PUBLIC RELATIONS (3)
 453. PUBLIC RELATIONS PROBLEMS (3)
 461. PHOTOGRAPHY FOR THE MASS MEDIA (3)
 473. INTERNATIONAL MASS COMMUNICATIONS (3)
 475. EVALUATION AND USES OF MASS COMMUNICATIONS RESEARCH (3)
 477. JOURNALISM IN THE SCHOOLS (3-6)
 485. INTERNSHIP (1-9)
 487. (Sp.Com. 487) MASS COMMUNICATIONS STUDY ABROAD (1-9)
 492. PUBLIC AFFAIRS BROADCASTING (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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504. SEMINAR IN THE HISTORY OF MASS COMMUNICATION (3)
 505. INTERNATIONAL COMMUNICATION PROBLEMS (3) Legal and communications problems of the international flow of news and opinion; international press codes.
 506. INTRODUCTION TO MASS COMMUNICATIONS RESEARCH (3) The scientific method; survey of basic concepts of theoretical and empirical research; variety of methodology; criteria for adequate research. *Mr. Barnes*
 508. THE LITERATURE OF JOURNALISM (3)
 511. MASS COMMUNICATIONS RESEARCH METHODS II (3) Problems of bibliographical research; evaluation of sources and materials in mass communications history, biography, structure, ethics, and other areas. Prerequisite: Journ. 506.
 513. CONSTITUTIONAL PROBLEMS OF THE NEWS MEDIA (3) Problems involving conflict between guarantees of press freedom in the First and Fourteenth Amendments and rights and privileges of others.
 521. NEWS MEDIA AND PUBLIC OPINION (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion.
 524. GOVERNMENT AND MASS COMMUNICATIONS (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Mr. Smith*
 540. SEMINAR IN ADVERTISING PROBLEMS (3) *Mr. Norris*
 585. COMPARATIVE THEORIES OF PRESS SYSTEMS (3) Institutional structure and normative functions of press systems in modern societies, as shaped by prevailing world view and social organization. *Mr. Norris*
 596. INDIVIDUAL STUDIES (1-6)
 597. SPECIAL TOPICS (1-6)

LABORATORY ANIMAL MEDICINE (L A M)

C. MAX LANG, *Chairman of the Department of Comparative Medicine*
The Milton S. Hershey Medical Center
Hershey, PA 17033

Degree Conferred: M.S.

Graduate Faculty: Senior Members Bullock and Lang.

Graduate Faculty: Associate Members Hughes and White.

The department offers a postdoctoral program for veterinarians leading to the Master of Science degree with a major in laboratory animal medicine. Laboratory animal medicine is a specialty of veterinary medicine that is concerned with the biology of laboratory animals and their comparative relationships to man. Postdoctoral training in this discipline provides a broad, basic foundation upon which the individual can build a career in teaching and research in laboratory animal medicine and/or in the professional direction of research animal facilities. The program has a strong research-oriented base with emphasis on comparative medicine and pathology.

The program requires two years for completion. Basically, the first year consists of formal course work, while the second year is devoted mainly to research and the development of clinical skills and techniques. A student must have earned a minimum of 12 credits in a major subject, 6 credits in a minor subject, and 6 credits of thesis research in order to receive the graduate degree. Approved minors have been established in anatomy, behavioral science, biological chemistry, microbiology, pathology, pharmacology, and physiology.

Students with a 3.00 junior-senior average, with a doctor of veterinary medicine degree, and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is offered only at The Milton S. Hershey Medical Center.

COMPARATIVE MEDICINE (C MED)

501. BIOLOGY AND CARE OF LABORATORY ANIMALS (2) Presentation of the anatomic and physiologic characteristics of the commonly used laboratory animal species and their relation to biomedical research.

503. LABORATORY ANIMAL GENETICS (2) Genetic principles applied to laboratory animals used for investigations of diseases that may be controlled or influenced by genetic factors.

505. LABORATORY ANIMAL ZOONOSSES (2) Experimentally induced, spontaneous, and infectious diseases transmissible between man and animals, with special emphasis on etiology, differential diagnosis, and control.

507. TECHNIQUES OF LABORATORY ANIMAL EXPERIMENTATION (2) Techniques of drug administration, infusion, and collection of body fluids and materials; gnotobiology; use of radioisotopes and bioinstrumentation.

510. ANIMAL PHYSIOLOGICAL SURGERY (3) Selected operative procedures, demonstrating principles of physiology with modern biomedical instrumentation, will be followed through the postoperative period.

515. EXPERIMENTAL SURGERY OF LABORATORY ANIMALS (3) Surgical techniques, including nephrectomy and Goldblatt clamp, bladder and gastric pouches, bile duct cannulation, intraventricular operation, cardiac and cerebrovascular catheterization.

530. DISEASES OF LABORATORY ANIMALS I (3) Physiological and pathological expressions of both infectious and metabolic-degenerative diseases of rodents, with emphasis on diagnostic and control methods.

531. **DISEASES OF LABORATORY ANIMALS II (3)** Physiological and pathological expressions of both infectious and metabolic-degenerative diseases of nonhuman primates and other species of animals.

535. **COMPARATIVE PATHOLOGY (3)** Comparative pathologic characteristics of infectious and metabolic disease of animals and man.

590. **COLLOQUIUM (1-3)**

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

LINGUISTICS (LING)

SIMON BELASCO, *In Charge of Graduate Programs in Linguistics*
310 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Belasco, Brault, Brubaker, Dalbor, Ebbinghaus, Holtzman, Magner, Martin, Morrill, Palermo, Schmalstieg, Smaby, and Sturcken.

Graduate Faculty: Associate Members Baldi, Buckalew, and Higgs.

A student majoring in linguistics may specialize in one of several flexible interdisciplinary graduate programs. The M.A. degree program includes general courses in historical linguistics, generative phonology and syntax, psycholinguistics, and acoustic phonetics. A candidate will also select, with the help of the graduate adviser, a coherent set of electives in a specialized area which may be a language or a related field. An acceptable thesis or paper must be submitted and a written comprehensive examination passed.

In addition to the courses required for the M.A. degree in linguistics (or the equivalent), each candidate for the Ph.D. degree must take the following courses: Ling. 503 if Ling. 504 is selected; Ling. 505 (Seminar in Historical Linguistics), Sp.Com. 520 (Seminar in Speech Science), and at least two 500-level courses in the structure, phonology, and history of a language or language family other than the native language if the specialty is in a related area, and at least five 500-level courses in the related area. If the specialty is in a language area, the student must take at least two 500-level courses in the structure, phonology, and history of a language or language family other than the native language or language area and at least five 500-level courses in the chosen language area. The specialized area will be selected by the candidate with the approval of the doctoral committee. The doctoral comprehensive examinations will be both written and oral and will cover the synchronic and diachronic aspects of general linguistics as well as the candidate's specialized area. The thesis must represent a significant contribution to linguistic knowledge. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of either French, German, Spanish, or Russian, and another major language related to the candidate's professional interests.

The minimum requirement for admission to an advanced degree program will normally be a B.A. degree in linguistics or an equivalent in any of the interdisciplinary subjects recognized as a specialized area.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

LINGUISTICS (LING)

400. **INTRODUCTION TO TRANSFORMATIONAL GRAMMAR (3)**

- 401. INTRODUCTION TO LINGUISTIC THEORIES (3)
- 402. HISTORICAL LINGUISTICS (3)
- 404. GENERATIVE PHONOLOGY (3)
- 413. (Sp.Com. 413) EXPERIMENTAL LINGUISTICS (3)
- 415. CONTRASTIVE ANALYSIS (3)
- 420. (Psy. 420) ADVANCED PSYCHOLINGUISTICS (3)
- 448. LANGUAGE VARIATION (3)
- 449. PROBLEMS IN TRANSFORMATIONAL SEMANTICS (3)
- 451. HISTORY OF THE GREEK LANGUAGE (3)
- 461. (Latin 461) HISTORY OF THE LATIN LANGUAGE (3)

500. GENERATIVE LINGUISTICS (3) Types of grammatical rules and their interrelations; algorithm for assigning structural descriptions; evaluation procedure for selecting best compatible grammar.

503. GENERATIVE SYNTAX (3) Grammatical rules specifying well-formed strings; conditions on analyzability and assigning of structural descriptions; deviation from well-formedness. Prerequisite: Ling. 400.

504. GENERATIVE PHONOLOGY (3) Distinctive feature theory in the generative framework; articulatory and acoustic correlates; nonphonemic features. Prerequisite: Ling: 400.

505. SEMINAR IN HISTORICAL LINGUISTICS (3) Detailed study of some problem of historical linguistics, e.g., the laryngeal theory, Indo-European ablaut, etc. Prerequisite: one course in historical linguistics.

517. (S.P.A. 517) APPLICATIONS OF LINGUISTICS TO COMMUNICATION DISORDERS (1) Application of linguistic theory to the understanding of communication disorders, with clinical implications for speech and language therapy. Prerequisites: 12 credits in speech pathology and audiology, psychology, linguistics, or phonetics.

520. (Psy. 520) SEMINAR IN PSYCHOLINGUISTICS (3) Consideration of theoretical and research issues relevant to psychological aspects of language sounds, syntax and semantics, and other cognitive support.

595. SEMINAR IN INTERDISCIPLINARY LINGUISTICS (3-12) Methods of research. Common and individual investigations in interdisciplinary fields of linguistics in consultation with one or more interdisciplinary instructors. Prerequisite: Ling. 400.

597. SPECIAL TOPICS (1-6)

MAN-ENVIRONMENT RELATIONS (M E R)

SIDNEY COHN, *Director of the Division*
S-126 Henderson Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Densmore, Lawton, Mann, Patterson, Powers, Studer, Vallance, and Wohlwill.

Graduate Faculty: Associate Members Cohn, Everett, Griffin, Loukissas, and Stover.

The Division has two degree programs, one leading to the Ph.D. degree in man-environment relations and the other to the D.Ed. degree in food service management.

The objective of the Ph.D. degree program in man-environment relations is to seek, through a broad-based analysis of complex environmental problems, an integrated understanding of man-environment systems, and to develop appropriate methods to plan and manage these systems. The multidisciplinary program is concerned with the analysis of the effects of the physical environment

upon human psychological, social, and biological functioning, and with the development of methods for organizing planned systems in response to social and behavioral goals. The research and instructional activities in the program focus on: (1) the relation of behavior to characteristics of environmental settings such as schools, housing and recreational facilities, and urban neighborhoods and communities; (2) environment-behavior relations in such functional systems as health care and transportation; and (3) the effects of planned intervention in the environment on individual and social behavior. These problems are considered with reference to the population in general, as well as special groups such as children, the aged, and the handicapped.

The program trains scientists for problem-oriented research dealing with environment-behavior systems. Instruction emphasizes the application of disciplinary information to problems arising from man's interaction with the physical environment. Doctoral students in the program are expected to acquire skills in a wide range of research and intervention methods and in techniques and theoretical perspectives of man-environment relations, and to develop the competency to generate applied research contributing to a body of knowledge of benefit to the design fields and social science alike.

Providing the appropriate multidisciplinary perspective are faculty with backgrounds in such fields as architecture, city and regional planning, operations research, urban design, social and experimental psychology, organizational behavior, and business administration. In addition to these full-time faculty, the division has available the resources of a group of adjunct faculty in diverse fields related to man-environment relations.

Recent graduates have taken positions with governmental and private research organizations dealing with environmental facilities, services, and problems and with colleges and universities with departments of architecture, planning, psychology, and environmental and urban studies.

Relevant undergraduate preparation may be in the design and planning professions, environmental and urban studies, and other programs in the physical, social, or behavioral sciences appropriate to the study of man-environment systems. Students with a 3.00 junior-senior grade-point average will be considered for admission. Exceptions to the minimum 3.00 average may be made for students with special backgrounds, abilities, and interests.

Students in the Ph.D. program may elect the dual-title degree program in operations research for the Ph.D. and M.S. degrees (see page p. 238).

The D.Ed. degree program in food service and housing administration equips its students to meet the critical need for educators qualified to staff programs and serve as department heads in hospitality education. The program has been designed to develop professional leadership in the field of hospitality education through a combination of study, research, and teaching experience. The applicant should possess a master's degree in food service and housing administration or a similar academic course of study. The course work leading toward the degree can be arranged to reflect the individual student's interests and prior educational experience. Although the course work can be drawn from appropriate disciplines throughout the University, the research emphasis focuses predominantly on food service administration and travel and lodging management.

MAN-ENVIRONMENT RELATIONS (M E R)

- 400. PROBLEMS IN MAN-ENVIRONMENT RELATIONS (1-6)
- 408. INTERMEDIATE TEXTILES (4)
- 409. INTERMEDIATE TEXTILES LABORATORY (1-3)
- 410. DIMENSIONS OF CLOTHING BEHAVIOR (3)
- 414. PLANNING COMMUNITY ENVIRONMENTS (3)
- 415. FUNCTIONAL CLOTHING DESIGN (3-12)
- 416. WESTERN COSTUME DEVELOPMENT FROM THE RENAISSANCE TO THE PRESENT (3)
- 435. (Psy. 435) ENVIRONMENTAL STIMULATION AND BEHAVIOR (3)
- 442. ANALYTIC METHODS IN MAN-ENVIRONMENT RELATIONS II (3)
- 447. (Soc. 447) ENVIRONMENTAL SOCIOLOGY (3)
- 452. MAN-ENVIRONMENT RELATIONS LABORATORY II (3)
- 453. MAN-ENVIRONMENT RELATIONS LABORATORY III (3)
- 471. HOUSING SPACE RELATED TO LIVING PATTERNS (3)
- 472. HOUSING PROBLEMS AND POLICIES (3)
- 480. METHODS FOR THE DESIGN OF ENVIRONMENT-BEHAVIOR SYSTEMS (3)

- 481. MANAGEMENT METHODS FOR ENVIRONMENT-BEHAVIOR SYSTEMS (3)
- 482. PLANNING METHODS FOR ENVIRONMENT-BEHAVIOR SYSTEMS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 500. NONTHESIS RESEARCH (1-6)
- 501. PROBLEMS IN MAN-ENVIRONMENT RELATIONS (1-9) Individual directed study, investigation, and practice in selected aspects of man-environment relations.
- 502. SEMINAR IN MAN-ENVIRONMENT RELATIONS (1-9)
- 503. RESEARCH METHODS AND EVALUATION IN MAN-ENVIRONMENT RELATIONS (1-9)
- 505. ENVIRONMENTAL-BEHAVIORAL PROGRAMMING, DESIGN, AND MANAGEMENT (3) Applications of findings in the behavioral sciences to environmental design and management strategies; empirical, theoretical, and methodological issues.
- 510. PSYCHOLOGICAL FOUNDATIONS OF THE STUDY OF ENVIRONMENT-BEHAVIOR RELATIONS (3) Seminar relating the psychology of perception, cognition, motivation, personality, attitude formation, and psychological stress to aspects of the physical environment.
- 512. BEHAVIOR ANALYSIS OF ENVIRONMENTAL PROBLEMS (3) Analysis of behaviors contributing to environmental dysfunction. Behavior change strategies are proposed to deal with such problem areas as transportation, pollution, overpopulation.
- 515. ENVIRONMENTAL SYSTEMS THEORY (3) An in-depth review of those elements of general systems theory relevant to the analysis and organization of man-environment settings.
- 516. QUANTITATIVE METHODS IN ENVIRONMENTAL MANAGEMENT (3) The use of operations research and systems analysis in the modeling of man-environment systems. Prerequisite: M.E.R. 515.
- 520. RECENT DEVELOPMENTS IN TEXTILES (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.
- 523. SOCIETAL DETERMINANTS IN CLOTHING AND TEXTILE DEVELOPMENT (1-6)
- 534. (Stat. 534) DYNAMIC PROGRAMMING (3) The study of the concepts underlying model-building and optimization of dynamic systems; applications to engineering, economic, and environmental systems. Prerequisites: Stat. 418; I.E. 405 or Q.B.A. 451.

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

- 402. FOOD SERVICE AND HOUSING LAYOUT AND DESIGN (3)
- 410. ADVANCED QUANTITY FOOD PRODUCTION (3)
- 412. FOOD AND BEVERAGE OPERATIONS (3)
- 435. FINANCIAL MANAGEMENT IN HOSPITALITY INDUSTRIES (3)
- 442. HOSPITALITY MERCHANDISING (3)
- 461. PERSONNEL FUNCTIONS IN FOOD SERVICE AND HOUSING ADMINISTRATION (3)
- 470. PROBLEMS IN FOOD SERVICE AND HOUSING ADMINISTRATION (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

MATHEMATICS (MATH)

GERALD LALLEMENT, *In Charge of Graduate Programs in Mathematics*
227 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Andrews, Armentrout, Axt, C. Ayoub, R. Ayoub, Deutsch, Farrell, Fine, Glasner, Hahn, Herman, Hunter, James, Jech, Kanwal, Krall, Lallement, Maserick, Morris, Olson, Rung, Stevens, Waterhouse, Wells, and Yood.

Graduate Faculty: Associate Members G. Anderson, J. Anderson, Bondy, Brownawell, Buhler, P. Chowla, Fulton, Huff, Mack, Mansfield, McCammon, Mills, O'Sullivan, Parsons, Sibley, Simpson, Ware, and Weisfeiler.

Graduate courses in all the principal branches of mathematics are offered regularly each year. The department is prepared to direct research in a variety of fields, including various branches of analysis, algebra, topology, number theory, applied analysis, and mathematical logic and foundations.

To be admitted to the Ph.D., D.Ed., or M.A. program without undergraduate deficiency, an applicant should have completed at least 18 credits in mathematics at the advanced undergraduate level (400 series or their equivalents). The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421), 6 in modern algebra (Math. 480-481), and 3 in topology (Math. 429) or their equivalents. These courses are essential preparation for the graduate program, and if they are taken after admission, a maximum of 6 credits may be counted toward an advanced degree.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

All Ph.D. students must take qualifying examinations in three fields of mathematics. Normally these examinations are taken before the beginning of the third year of graduate study. Recommendations for advancement to Ph.D. candidacy are based on these examinations together with performance in the first two years of study. The comprehensive examination is given after approximately 60 credits are earned and after the student has passed reading examinations in two languages chosen from French, Russian, or German. The Ph.D. student is also expected to enroll in advanced seminars.

Outstanding students who do not continue in the doctoral program may petition the department for further support in order to pursue a second master's degree in another area to which mathematics is applicable.

For the D.Ed. degree, a student must pass qualifying examinations in algebra and analysis and a reading examination in French, German, or Russian before taking the comprehensive examination. In addition to the major thesis, the department requires participation in two terms of research seminar, but no minor thesis is required. The D.Ed. program is intended for college teachers. Three years of experience in professional mathematics teaching on a full-time basis is required for admission. (Graduate teaching assistants are not included in this category.)

For the M.A. degree the department offers two options: (1) the thesis option requires 12 credits of approved 500-series courses in mathematics, 6-9 credits of thesis, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a final oral examination based on the thesis and general course material; and (2) the nonthesis option requires 18 credits of 500-series courses in mathematics with a grade of A or B, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a term paper on an approved topic in mathematics. No final examination is given in this option. A student choosing the program option in operations research must complete a thesis.

To be admitted to the M.Ed. program without undergraduate deficiency, an applicant should have completed at least 15 credits in mathematics at the intermediate level beyond calculus. The M.Ed. program does not require any 500-series courses, but the student is encouraged to select some at this level. Special courses have been instituted for the training of teachers. Among these are Math. 400, 401-402, 416, 425-426, and 470-471. These are acceptable for the satisfaction of credit requirements only for the M.Ed. degree.

Entering graduate students in mathematics for whom English is not the first language are required to

have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. Furthermore, the results of this examination must be received by the Department of Mathematics at least six months prior to the requested date of admission to the Graduate School.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.A. degrees (see p. 238).

A brochure describing more fully the graduate program in mathematics is available from the Department of Mathematics.

MATHEMATICS (MATH)

- 400. PROBABILITY FOR TEACHERS (3)
- 401-402. GEOMETRY FOR TEACHERS (3 each)
- 404. THEORY OF NUMBERS (3)
- 405. (A.M. 405) FOURIER SERIES AND PARTIAL DIFFERENTIAL EQUATIONS (3)
- 406. TOPICS IN THEORY OF NUMBERS (3)
- 409. (Stat. 409) INTRODUCTION TO PROBABILITY THEORY (3)
- 410. (Stat. 410) MATHEMATICAL STATISTICS I (3)
- 411. FINITE DIFFERENCES (3)
- 412. (Stat. 412) MATHEMATICAL STATISTICS II (3)
- 414. MATHEMATICS OF SCIENCE FOR TEACHERS (3)
- 416. MATHEMATICAL LOGIC FOR TEACHERS (3)
- 417. (A.M. 417) TENSOR ANALYSIS (3)
- 418. (A.M. 418, Stat. 418) DISCRETE PROBABILITY THEORY (3)
- 420. INTRODUCTION TO ANALYSIS I (3)
- 421. INTRODUCTION TO ANALYSIS II (3)
- 422. ALGEBRAIC GEOMETRY (3)
- 423. METRIC DIFFERENTIAL GEOMETRY (3)
- 425-426. ANALYSIS FOR TEACHERS (3 each)
- 427. (Stat. 427) DISCRETE STOCHASTIC MODELS (3)
- 428. (Phil. 428) LOGICAL THEORY (3)
- 429. GENERAL TOPOLOGY (3)
- 430. ELEMENTARY ALGEBRAIC TOPOLOGY (3)
- 431. (A.M. 431) ORDINARY DIFFERENTIAL EQUATIONS (3)
- 435. AXIOMATIC SET THEORY (3)
- 441. (A.M. 441) MATRIX ALGEBRA (3)
- 452. (A.M. 452) FUNCTIONS OF A COMPLEX VARIABLE (3)
- 453. (Cmp.Sc. 453) NUMERICAL COMPUTATIONS (3)
- 454. (Cmp.Sc. 454) MATRIX COMPUTATIONS (3)
- 456. COMPUTABILITY AND UNSOLVABILITY (3)
- 465. CLASSICAL ANALYSIS I (3)
- 466. CLASSICAL ANALYSIS II (3)
- 470-471. ALGEBRA FOR TEACHERS (3 each)
- 472. FOUNDATIONS OF GEOMETRY (3)
- 480. BASIC ABSTRACT ALGEBRA (3)
- 481. LINEAR ALGEBRA (3)
- 484. LINEAR PROGRAMS AND RELATED PROBLEMS (3)
- 489. MATHEMATICS SEMINAR (1-6)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501-502. THEORY OF FUNCTIONS OF A REAL VARIABLE (3 each) Sets, metric spaces, measure and integration, L_p spaces and other function spaces, differentiation. Prerequisite: Math. 421.
- 505. INTEGRAL EQUATIONS (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. 421.
- 506. DISTRIBUTIONS AND GENERALIZED FUNCTIONS (3) Schwartz-Sobolev theory of distributions,

tempered distributions, Fourier transforms, fundamental solutions of ordinary and partial differential equations; applications. Prerequisites: Math. 405 or 431; Math. 420.

507. CALCULUS OF VARIATIONS AND OPTIMAL CONTROL (3) Classical and modern theory of the calculus of variations; problems in optimal control. Prerequisite: Math. 421.

508-509. COMPLEX ANALYSIS (3 each) Analytic and meromorphic functions; Riemann's mapping theorem. Prerequisite: Math. 421.

511. LINEAR ALGEBRA (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisite: Math. 481 or 537.

515. PARTIAL DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: Math. 421.

516. ADVANCED PARTIAL DIFFERENTIAL EQUATIONS (3) Elliptic operators, fundamental solutions, weak and strong derivatives, Sobolev inequalities, Dirichlet problem, equations of evolution, semigroups. Prerequisites: A.M. 511, Math. 515.

517-518. (Stat. 517-518) PROBABILITY THEORY (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

520. PROJECTIVE GEOMETRY (3) General study of the subject from the synthetic and analytic standpoint. Prerequisites: Math. 472, 480.

521. ANALYTIC NUMBER THEORY I (3) Improvements of the prime number theorem, L-functions and class numbers, asymptotic and arithmetic properties of coefficients of modular forms. Prerequisites: Math. 508, 594.

522. ANALYTIC NUMBER THEORY II (3) Distribution of primes, analytic number theory in algebraic number fields, transcendental numbers, advanced theory of partitions. Prerequisite: Math. 521.

523. DIFFERENTIAL GEOMETRY (3) Manifolds-differentiable structures, tangent spaces, connections, structural equations, Riemannian geometry. Prerequisite: Math. 429.

524. ADVANCED COMPLEX ANALYSIS (3) Topics include boundary behavior of analytic functions, bounded analytic functions, conformal mapping, theory of Riemann surfaces. Prerequisite: Math. 509.

525. THEORY OF FUNCTIONS OF SEVERAL COMPLEX VARIABLES (3-6) Topics include fundamental properties of holomorphic functions, complex analytic manifolds, integral representations, Cousin problems. Prerequisite: Math. 509.

526. THEORY OF SHEAVES (3) Presheaves over topological spaces; defining sheaves two ways; Čech cohomology of presheaves; cohomology of sheaves; flasks; Lubkin's punctual cochains. Prerequisites: Math. 429; Math. 480 or 535.

527. ALGEBRAIC GEOMETRY (3) Preschemes and pro-schemes; products; projective finite and affine presentation maps; projective quasicohherent sheaves; cohomology of quasicohherent sheaves over affine schemes. Prerequisite: Math. 526.

528. UNIFORM SPACES AND FUNCTION SPACES (3) Uniform spaces, completion, compactifications, function spaces, metrization. Prerequisite: Math. 429.

529-530-531. TOPOLOGY (3 each) Topological, product, compact, metric, and connected spaces; continuous functions; separation axioms, countability conditions, combinatorial topology.

532. THEORY OF SETS (3) Formal development of set theory on a logical basis and related methodological problems; applications to the foundations of mathematics. Prerequisite: Math. 554 (Phil. 554); Math. 556.

535-536-537. ALGEBRA (3 each) Basic theory of semigroups and groups, rings and modules, fields, lattices.

538. COMMUTATIVE ALGEBRA (3) Topics selected from noetherian rings and modules, primary decompositions, Dedekind domains and ideal theory, other special types of commutative rings or fields. Prerequisite: Math. 536.
539. RINGS (3) Selected topics from the theory of rings. Prerequisite: Math. 536.
542. (Stat. 542) STATISTICAL DISTRIBUTION THEORY IN SCIENTIFIC WORK: I. DISCRETE MODELS (3) Statistical distributions arising in scientific modeling and statistical inference; structures, interrelations, characterizations, and simulation with practical examples. Prerequisite: Math. (Stat.) 410; knowledge of matrix algebra.
543. (Stat. 543) STATISTICAL DISTRIBUTION THEORY IN SCIENTIFIC WORK: II. CONTINUOUS MODELS (3) Statistical distributions arising in scientific modeling and statistical inference; structures, interrelations; characterizations, and simulation with practical examples. Prerequisite: Math. (Stat.) 542.
- 547-548-549. LIE THEORY (2 each) Topics selected from theory of topological semigroups, topological groups, lie groups, transformation groups. Prerequisite: Math. 531.
551. (Cmp.Sc. 551) NUMERICAL ALGEBRA (3) Zeros of polynomials; iterative solution of linear and nonlinear systems; sparse matrix techniques; eigenvalues and eigenvectors. Prerequisite: Cmp.Sc. 454 or Math. 441.
552. (Cmp.Sc. 552) INTRODUCTION TO APPROXIMATION THEORY (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420 and 3 credits in computer science.
553. (Cmp.Sc. 553) NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS (3) Methods for initial value and boundary value problems. Stability and convergence analysis, automatic error control, and stiff systems. Prerequisites: Cmp.Sc. 453, Math. 431.
554. (Phil. 554) LOGIC AND METAMATHEMATICS (3) Completeness, Lowenheim-Skolem and compactness theorems. First-order arithmetic, recursiveness and the incompleteness and consistency of arithmetic. Prerequisite: Math. 428.
556. RECURSION THEORY (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions; recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Math. 554 (Phil. 554).
557. MODEL THEORY (3) Countable models, saturated models, categorical theories and related topics. Prerequisites: Math. 532, 556.
559. (Stat. 559) THEORY OF STOCHASTIC PROCESSES (3) Stationary, independent, and orthogonal processes; discrete and continuous Markov processes; martingales and semi-martingales applications. Prerequisite: Math. 518.
- 560-561. THEORY OF DIFFERENTIAL EQUATIONS (3 each) Topics selected from existence and uniqueness of solutions of differential systems, Sturm-Liouville systems, eigenvalue problems, integral operator solution. Prerequisites: Math. 72 or 83 or 100; Math. 508.
562. THEORY OF SPECIAL FUNCTIONS (3) Topics include asymptotic expansions; Riemann-Papperitz and Trusdell's F equations; orthogonal polynomials; generating, beta, zeta, hypergeometric, Bessel, Legendre, elliptic functions. Prerequisites: Math. 72 or 83 or 100 and either Math. 420 and 452, or Math. 508.
563. APPROXIMATION THEORY (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds; degree of approximation; approximation of linear functionals. Prerequisites: Math. 453, 501.
564. (Cmp.Sc. 564) NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS (3) Methods of parabolic, hyperbolic, and elliptic partial differential equations; finite difference and variational methods; splines, finite elements. Prerequisites: Cmp.Sc. 453, 454; A.M. 451 or Math. 405.
565. FUNCTIONAL ANALYSIS (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 502.

566. ALGEBRAIC NUMBER THEORY I (3) Dedekind rings; cyclotomic and Kummer extensions; valuations; ramification, decomposition, inertial groups; Galois extensions; locally compact groups of number theory. Prerequisites: Math. 537, 594.
567. ALGEBRAIC NUMBER THEORY II (3) Local and global class field theory; integral quadratic forms; algebraic and arithmetic groups; algebraic function of one variable. Prerequisite: Math. 566.
568. ADVANCED ALGEBRA I (3) Noetherian and Artinian modules and rings, simple and semi-simple modules and rings, radicals. Prerequisite: Math. 537.
569. ADVANCED ALGEBRA II (3) Multilinear algebra, commutative algebra, homological algebra. Prerequisite: Math. 568.
570. SPECIAL TOPICS IN GEOMETRY (3-12)
571. SPECIAL TOPICS IN ANALYSIS (3-12)
572. SPECIAL TOPICS IN ALGEBRA (3-12)
573. SPECIAL TOPICS IN APPLIED MATHEMATICS (3-12)
574. SPECIAL TOPICS IN FOUNDATIONS OF MATHEMATICS (3-12)
- 575-576. MATHEMATICS SEMINAR (1-6 each) Selected topics from recent mathematical developments.
578. SPECIAL TOPICS IN TOPOLOGY (3-12)
579. (Cmp.Sc. 579) SPECIAL TOPICS IN NUMERICAL ANALYSIS (2-12)
580. SPECIAL TOPICS IN NUMBER THEORY (2-12)
- 581-582. GROUP THEORY I, II (3 each) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 535.
583. HOMOLOGICAL ALGEBRA (3) Modules, diagrams, functors, homology of complexes, resolutions, cohomology of groups, tensor and torsion products. Prerequisite: Math. 536.
- 584-585-586. ALGEBRAIC TOPOLOGY (2 each) Development of singular and Čech homology and cohomology theories; homotopy and cohomotopy theories. Prerequisite: Math. 531.
590. COLLOQUIUM (1-3)
- 592-593-594. NUMBER THEORY (3 each) Congruences, quadratic residues, arithmetical functions, Dirichlet's theorem, prime number theorem, classical multiplicative ideal theory, partitions, valuations and p-adic numbers, divisors. Prerequisite: Math. 480. Prerequisite or concurrent: Math. 508.
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2)

NOTE: *Courses in Applied Mathematics, Computer Science, and Statistics are listed separately.*

MATHEMATICS (MATH)

HELMUT E. WEBER, *In Charge of the Graduate Program in Mathematics*
King of Prussia Graduate Center, King of Prussia, PA 19406

Degree Conferred: M.Ed.

Graduate Faculty: Associate Members Callahan, Duncan, and Llorens.

The program is offered specifically to permit teachers in the area to pursue advanced studies through evening classes while employed in teaching. Courses offered for the program are established and controlled by the resident departments at the University Park Campus.

Credit requirements may be satisfied by completing a minimum of 18 credits in approved mathematics courses, a minimum of 6 credits in approved mathematics and science courses, and a minimum of 6 credits in approved education courses. In addition, a term paper is required. All requirements must be met within six years or seven consecutive summers.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. An applicant must have a bachelor's degree and have completed 27 credits in mathematics including at least 15 credits at the intermediate level beyond calculus. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details concerning this program may be obtained by writing directly to the King of Prussia Graduate Center.

MECHANICAL ENGINEERING (M E)

DONALD R. OLSON, *Head of the Department*
207 Mechanical Engineering Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Brickman, Cunningham, Faeth, Heinsohn, Henderson, Henry, Kuo, Lestz, Olson, Park, Reethof, Schmidt, Shearer, Wambold, Weber, and Wolgemuth.

Graduate Faculty: Associate Members DeCarolis, Laananen, and Parke.

Graduate programs and research facilities are available in thermodynamics and combustion, heat transfer, fluid mechanics, dynamic system analysis, mechanical design, biomedical engineering, and energy systems. Air pollution control, automotive safety, designing for noise control and for reliability also provide many research and design opportunities.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an in-depth study of one foreign language (6 credits), by taking two or more courses (minimum of 6 credits) of a nontechnical nature in a single area of study appropriate and related to the student's career orientation, or by taking an advanced technical writing course (Engl. 418 — 4 credits) and presenting a formal proposal for thesis research (M.E. 580 — 2 credits) to the doctoral committee.

A student working toward an M.S. degree may choose one of the following options: (1) a minimum of 24 course credits plus 6 thesis credits (M.E. 600) culminating in the submission of a thesis to the Graduate School, (2) a minimum of 30 course credits plus a technical report, or (3) a minimum of 30 course credits plus submission of a Ph.D. thesis research proposal, provided the student has passed the candidacy examination.

The entering student must hold a bachelor's degree in engineering or physical science. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MECHANICAL ENGINEERING (M E)

- 400. HONORS THESIS (1-3)
 - 401. MECHANICAL ENGINEERING (3-12)
 - 403. ROCKET PROPULSION (3)
 - 405. AIR POLLUTION CONTROL SYSTEMS (3)
 - 409. GAS TURBINES (3)
 - 410. POWER PLANTS (3)
 - 411. REFRIGERATION AND AIR CONDITIONING (3)
 - 412. HEAT TRANSFER (3)
 - 413. INTERNAL COMBUSTION ENGINES (3)
 - 414. ENGINEERING ANALYSIS OF THERMAL SYSTEMS (3)
 - 415. ENGINEERING ANALYSIS FOR MECHANICAL DESIGN (3)
 - 417. THEORY OF ENGINEERING INSTRUMENTS (3)
 - 418. PRINCIPLES OF TURBOMACHINERY (3)
 - 421. (Aersp. 421) INTERMEDIATE VISCOUS FLOW (3)
 - 450. DESIGN OF MACHINE TOOLS (3)
 - 451. ADVANCED MACHINE DESIGN PROBLEMS (3)
 - 452. DESIGN ANALYSIS (3)
 - 454. ADVANCED MACHINE DYNAMICS (3)
 - 455. AUTOMATIC CONTROL SYSTEMS (3)
 - 458. NOISE CONTROL IN MACHINERY (3)
 - 460. RELIABILITY CONCEPTS IN DESIGN (3)
 - 470. FUNDAMENTALS OF AIR POLLUTION (3)
 - 472. ENGINEERING AND ADMINISTRATION OF AIR POLLUTION CONTROL (8)
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- 503. THERMODYNAMIC PROCESS ANALYSIS (3) Development of equations governing separate processes in complete machines to give basic system parameters and characteristics; transient processes; irreversible effects.
 - 504. ADVANCED ENGINEERING THERMODYNAMICS (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject.
 - 506. SELECTED TOPICS IN MECHANICAL ENGINEERING (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.
 - 512. HEAT TRANSFER — CONDUCTION (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions.
 - 513. HEAT TRANSFER — CONVECTION (3) Laminar and turbulent flow heat transfer in natural and forced convection systems.
 - 514. HEAT TRANSFER — RADIATION (3) Thermal radiation fundamentals; specular and diffuse systems; differential and integral methods; numerical techniques; industrial applications.
 - 515. TWO-PHASE HEAT TRANSFER (3) Heat transfer processes involving evaporation, boiling, and condensation.
 - 516. COMBUSTION IN PROPULSION SYSTEMS (3) Theoretical formulations and methods of solution of engineering problems and physical processes in chemical propulsion systems.
 - 519. COMPRESSIBLE FLUID FLOW (2-4) Two-dimensional subsonic flow; similarity rules; theory of characteristics; supersonic and hypersonic flows; nonsteady flow; oblique shock waves.
 - 521. ELECTROMAGNETIC AND THERMODYNAMIC FLOW SYSTEMS (3) Thermodynamic equations for flow of reacting and nonreacting fluids in electromagnetic fields; applications to engineering problems.
 - 522. BOUNDARY LAYER AND SEPARATED FLOWS (3) Behavior of viscous fluids, with emphasis on boundary layer and separation effects in internal flow.
 - 540. NUMERICAL SOLUTIONS APPLIED TO HEAT TRANSFER AND FLUID MECHANICS PROBLEMS (3)

Application of finite difference methods to the study of potential and viscous flows and conduction and convection heat transfer.

552. **ADVANCED DYNAMICS OF MACHINES (3-6)** Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.

555. **AUTOMATIC CONTROL SYSTEMS (3)** Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.

557. **MECHANISM SYNTHESIS (3)** Geometrical and algebraic methods for synthesizing planar and spatial mechanisms, dynamics of spatial mechanism.

558. **FLUID CONTROL SYSTEMS (2)** Modeling fluid system dynamic performance, experimental determination of the actual behavior, and comparison of predicted behavior with actual behavior. Prerequisite: M.E. 455.

560. **PROBABILISTIC METHODS IN MACHINE DESIGN (2)** Application of statistical methods and probability theory to machine design. Stochastic aspects of performance and mechanical failure of dynamic systems. Prerequisites: Math. 409 or M.E. 460 or I.E. 323; M.E. 42, 54.

562. **SIMULATION OF MECHANICAL SYSTEMS (3)** Introduces computational fundamentals, including digital logic; programming language, basic numerical analysis and data processing, as applied to mechanical simulation techniques. Prerequisites: M.E. 54, 66.

571. **AIR POLLUTION SEMINARS (1-2)** Weekly seminars featuring the contributions of many different disciplines to the solution of air pollution and other environmental problems.

580. **INVESTIGATION PROJECTS (1-6)** Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

METALLURGY (METAL)

HOWARD W. PICKERING, *In Charge of Graduate Programs in Metallurgy*
209 Steidle Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bitler, Hoke, Muan, Pickering, Ryba, Simkovich, and Thrower.

Graduate Faculty: Associate Members Macmillan, Osseo-Asare, and Robison.

This program is one of the options in which a graduate student in the Department of Materials Science and Engineering can receive an advanced degree. A student may specialize, through both course work and research, in the science and engineering aspects of chemical, physical, or mechanical metallurgy.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language together with courses from other designated areas.

Suitable preparation for graduate study in this program may be found in one of the material sciences such as ceramic science, fuel science, metallurgy, or solid state science; in engineering fields such as chemical or mechanical engineering; in basic physical sciences such as chemistry or physics; or in earth sciences such as geochemistry and mineralogy. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METALLURGY (METAL)

401. **METALLURGICAL PROCESSES AND KINETICS (3)**

402. **CORROSION ENGINEERING (3)**

403. PHYSICAL METALLURGY LABORATORY (1)
 404. DESIGN OF PYROMETALLURGICAL SYSTEMS (3)
 405. PHYSICAL METALLURGY (3)
 406. ALLOY SYSTEMS (3)
 407. SOLIDIFICATION PROCESSING (3)
 408. DEFORMATIONAL PROCESSING (3)
 410. METALLURGICAL INVESTIGATIONS AND DESIGN (1-6)
 412. SOLID STATE METALLURGY (3)
 414. EXTRACTIVE METALLURGY LABORATORY (1)
 416. HYDROMETALLURGY LABORATORY (1)
 426. HYDROMETALLURGY (3)
 459. METALLURGICAL APPLICATIONS FOR ENGINEERS (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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501. METALLURGICAL PROBLEMS (1-6 per term) Independent study of special problems in metallurgy.
 508. KINETICS OF PHASE TRANSFORMATIONS (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates. *Mr. Bitler*
 509. INTRODUCTORY THEORETICAL PHYSICAL METALLURGY (3) Quantum mechanics and its application to solid-state theory; introduction of Schroedinger's equation, its solutions, free-electron model, band model. *Mr. Bitler*
 510. MAGNETIC AND TRANSPORT PROPERTIES OF MATERIALS (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: Metal. 509. *Mr. Bitler*
 513. ADVANCED CHEMICAL METALLURGY I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites: Chem. 452, Metal. 301, 402, 404. *Mr. Simkovich*
 514. DISLOCATION THEORY (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Mr. Bitler*
 515. CORROSION OF METALS (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments. *Mr. Pickering*
 516. FLOW AND FRACTURE OF SOLIDS (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisite: Metal. 514. *Mr. Macmillan*
 518. HETEROGENEOUS EQUILIBRIA AT HIGH TEMPERATURES (2-3) Treatment of high-temperature equilibria in metal and oxide systems involving crystalline, liquid, and gas phases. Prerequisite: Metal. 513. *Mr. Muan*
 519. ADVANCED CHEMICAL METALLURGY II (3) Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: Metal. 513. *Mr. Robison*
 520. FOUNDRY METALLURGY (3) Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisite: Metal. 513. *Mr. Robison*
 522. SOLID-PHASE REACTIONS IN METALS (3) Mechanisms and rate-determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisite: Metal. 508. *Mr. Bitler*
 535. (E.Mch. 535) CRYSTAL DEFECTS AND MECHANICAL RESPONSE (3) Mechanical responses of crystalline solids containing point, line, and interfacial defects; elastic and plastic responses. Prerequisite: Metal. 514 or E.Mch. 414.

NOTE: Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Materials Science.

METEOROLOGY (METEO)

ALFRED K. BLACKADAR, *Head of the Department*
503 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthes, Blackadar, R. de Pena, Dutton, Hosler, Norman, Panofsky, and Thomson.

Graduate Faculty: Associate Members Cahir, Clark, Fraser, Olivero, and J. Pena.

Candidates may specialize in the study of problems in either theoretical or applied meteorology including such areas as cloud physics, various phases of dynamic meteorology and geophysical fluid dynamics including turbulence and atmospheric circulation, numerical modeling, macro- and micro-climatology, synoptic meteorology, or meteorological instrumentation. The department also encourages interdisciplinary studies in such fields as agricultural meteorology, biometeorology, water resources, air pollution, and fluid mechanics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of German or Russian. The thesis or paper option is available for the M.S. degree.

Requirements for admission include mathematics through differential equations and one year of college physics. Undergraduate study of meteorology is not required for admission. Special programs are available to encourage the graduate study of meteorology by all students with strong backgrounds in mathematics, physics, or engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METEOROLOGY (METEO)

- 400. METEOROLOGY FOR TEACHERS (3)
- 401. PHYSICAL CLIMATOLOGY FOR TEACHERS (3)
- 404. MOTIONS OF THE ATMOSPHERE AND OCEANS (3)
- 407. ELEMENTS OF PHYSICAL OCEANOGRAPHY (3)
- 411. INTRODUCTION TO SYNOPTIC METEOROLOGY (3)
- 418. INTRODUCTORY PHYSICS OF THE UPPER ATMOSPHERE (3)
- 420. TROPICAL METEOROLOGY (3)
- 430. INTRODUCTION TO SYNOPTIC METEOROLOGY LABORATORY (3)
- 431. SYNOPTIC METEOROLOGY LABORATORY I (3)
- 432. SYNOPTIC METEOROLOGY LABORATORY II (2-10)
- 433. ADVANCED SYNOPTIC ANALYTICAL TECHNIQUES (3)
- 434. APPLICATION OF METEOROLOGICAL SATELLITE DATA TO ANALYSIS AND FORECASTING (3)
- 442. OBSERVING METEOROLOGICAL PHENOMENA (3)
- 443. PHYSICAL METEOROLOGY (3)
- 445. HYDROLOGY FOR METEOROLOGISTS (3)
- 450. APPLICATIONS OF STATISTICS TO METEOROLOGY (3)
- 451. INTRODUCTION TO DYNAMIC METEOROLOGY (3)
- 452. HYDRODYNAMICS OF THE ATMOSPHERE (3)
- 453. ATMOSPHERIC THERMODYNAMICS (3)
- 461. THEORY OF METEOROLOGICAL INSTRUMENTS (3)
- 472. PHYSICAL AND DYNAMIC CLIMATOLOGY (3)
- 473. INTRODUCTION TO MICROMETEOROLOGY (3)
- 475. CHEMISTRY OF THE ATMOSPHERE (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

502. **SELECTED TOPICS OF ADVANCED METEOROLOGY** (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.
503. **ATMOSPHERIC TURBULENCE** (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.
505. **BIOLIMATOLOGY** (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.
506. **ADVANCED METEOROLOGICAL ANALYSIS** (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.
507. **DYNAMIC OCEANOGRAPHY** (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.
508. **PHYSICS OF THE UPPER ATMOSPHERE** (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.
509. **THEORETICAL CLIMATOLOGY** (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.
510. **CLOUD PHYSICS** (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.
520. **INDIRECT ATMOSPHERIC PROBING** (3) Analysis and description of measurements made with radar and bistatic radio, optical and acoustic systems used for indirect atmospheric sounding. Prerequisite: Meteo. 443.
550. **ATMOSPHERIC MOTIONS** (3) Fundamental properties and conservation requirements of the hydrodynamic equations; elements of advanced dynamic meteorology and applications to atmospheric dynamics. Prerequisite or concurrent: A.M. 451.
551. **ATMOSPHERIC WAVE MOTION** (2-3) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 550.
552. **NUMERICAL WEATHER PREDICTION** (2-3) Finite difference and spectral methods, barotropic and baroclinic models, filtered and primitive equation models, synoptic-scale and mesoscale models. Prerequisite: Meteo. 550.
553. **ENERGETICS OF ATMOSPHERIC MOTION** (2-3) Theoretical investigation of the conversions of energy in the atmosphere; maintenance of the general circulation and global thermodynamics. Prerequisite: Meteo. 550.
555. **ATMOSPHERIC DIFFUSION** (2-3) Dispersion of atmospheric contaminants; experiments, theory and practical implications for air pollution problems. Prerequisite: 3 credits of statistics.
561. **CHEMISTRY OF THE ATMOSPHERE** (2) Fundamental knowledge of chemical characteristics of atmospheric components and transformations, in connection with cloud microphysics, circulation, and air pollution. Prerequisite: 3 credits in chemistry.
597. **SPECIAL TOPICS** (1-6)

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Materials Science.*

MICROBIOLOGY (MICRB)

L. N. ZIMMERMAN, *Head of the Department of Microbiology and Cell Biology*
S-101 Frear Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Casida, Ceglowski, Docherty, Gaffney, Ginoza, Lindstrom, Ludwig, Pootjes, Tershak, Zarkower, and Zimmerman.

Graduate Faculty: Associate Members Kolenbrander, McDonel, Schlegel, Stevens, and Yasbin.

Opportunities for graduate study are available in microbiology, immunology, virology, and cell biology. Among current areas of research are included such topics as bacterial ecology, genetics, and physiology; food and industrial microbiology; photosynthesis of procaryotes; chemical and pathogenic properties of both bacterial and animal viruses; viral and tumor immunology; and mammary carcinogenesis. There is opportunity for cooperative research with other departments.

The communication and foreign language requirement for the Ph.D. may be satisfied by intermediate knowledge of one foreign language (French, German, or Russian).

Prerequisites for admission are 16 credits in inorganic and organic chemistry, 6 in physics, 4 in microbiology, and mathematics through calculus. Admission may be granted with deficiencies up to 8 credits, to be made up while pursuing graduate work. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. A satisfactory score on the Graduate Record Examination is required for admission.

MICROBIOLOGY (MICRB)

400. INTRODUCTORY ENVIRONMENTAL MICROBIOLOGY (2)
401. ADVANCED BACTERIOLOGY (2)
407. PROBLEMS IN MICROBIOLOGY (1-12)
408. LABORATORY INSTRUCTIONAL PRACTICE (1-2)
410. IMMUNOLOGY AND SEROLOGY (2)
411. SURVEY OF MICROBIOLOGY (1 per term)
412. MEDICAL MICROBIOLOGY (2)
413. MICROBIAL SOIL ECOLOGY (2)
414. FOOD MICROBIOLOGY (2-4)
415. INTRODUCTION TO ANIMAL VIRUSES (2)
416. INDUSTRIAL MICROBIOLOGY (2)
417. EPIDEMIOLOGY (2)
418. BACTERIAL VIRUSES (2)
421. LABORATORY OF GENERAL AND APPLIED MICROBIOLOGY (2)
422. PRACTICAL MEDICAL MICROBIOLOGY (2)
474. ADVANCED CELL BIOLOGY (2)
476. THE PHOTOSYNTHETIC PROCESS (3)

507. SEMINAR (1 per term) Reports on current fields of research.
508. BACTERIAL PHYSIOLOGY (2-4) Contributions of environment, finestructure, and metabolism to the functioning cell. Prerequisite: 6 credits of biochemistry.
510. ADVANCED IMMUNOLOGY (2) Discussions of the modern concepts in immunology. Emphasis on areas of current interest. Prerequisites: Micrb. 410, 6 credits in biochemistry.
512. MICROBIOLOGICAL METHODS (1-6) Practice in special laboratory techniques of modern microbiology.
516. BACTERIAL GENETICS (2-4) Mechanisms of variation in microorganisms including mutation,

adaptation, sexual recombination, transduction, and transforming factors. Prerequisites: 3 credits each in microbiology and genetics.

520. **BIOCHEMICAL VIROLOGY (2)** Role of enzymes and nucleic acids in virus synthesis. Regulation of virus reproduction in animal and bacterial cells. Prerequisite: 6 credits of biochemistry.

529. (C.E. 579) **AQUATIC MICROBIOLOGY (3)** Ecology and physiology of microorganisms of inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.

602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

MICROBIOLOGY (MICRO)

FRED RAPP, *Chairman of the Department*
The Milton S. Hershey Medical Center
Hershey, PA 17033

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Geder, Hyman, Kreider, Rapp, and Taylor.

Graduate Faculty: Associate Members Bartlett, Carter, Isom, Lipton, Marquez, St. Jeor, and Tenser.

This program is oriented to the study of the general areas of bacteriology, virology, and immunology. Active research programs exist in a variety of subdivisions of these disciplines. Some areas emphasized include the replication and structure of viral nucleic acids, the role of viruses in tumor formation, viral latency in mammalian systems, tumor immunology, electron microscopy of viruses and virus-infected cells, and eucaryotic gene regulation.

The communication and foreign language requirement may be satisfied by demonstrating competence in one foreign language, such as French, German, or Russian. Alternatively, with special permission, courses which enhance communication skills can be substituted for the foreign language requirement.

Qualified students with undergraduate preparation in either the biological, biochemical, or physical sciences may apply. An adequate background in biology, chemistry, and mathematics and an overall grade-point average of 3.00 or better are required.

The best-qualified applicants will be accepted on a space-available basis. Formal applications should contain two letters of recommendation and a brief personal essay summarizing the background and professional goals of the applicant. Graduate Record Examination scores are required.

This program is offered only at The Milton S. Hershey Medical Center.

MICROBIOLOGY (MICRB)

551. **MEDICAL MICROBIOLOGY (3)** Principles of medical microbiology: bacterial structure and function, host-parasite relationships, and bacteria, fungi, and viruses causing human disease.

552. **MEDICAL MICROBIOLOGY LABORATORY (1)** Laboratory exercises to augment Micrb. 551. Laboratory tests used to characterize microorganisms and to aid in diagnosis of disease. Concurrent: Micrb. 551.

553. **SCIENCE OF VIROLOGY (3)** Replication of viruses and effect on host, including transfer of genetic information, immunology, and oncogenic properties of viruses.

554. **PRINCIPLES OF IMMUNOLOGY (2)** Study of immune response. Nature of antigens, structure, function of antibodies, hypersensitivity, transplantation and tumor immunology, autoimmunity, and immunosuppression.

555. **MICROBIAL PHYSIOLOGY AND METABOLISM (3)** Physiology and comparative biochemistry of

microorganisms, especially human pathogens. Regulatory mechanisms, energy metabolism, and other topics essential for cell replication.

556. **MOLECULAR GENETICS (3)** Structure, synthesis, and function of DNA, RNA, and proteins. Emphasis on gene structure and function in the eucaryotic cell.

557. **ELECTRON MICROSCOPY (3)** The application of electron microscopy to microbiology, including specimen preparation, use of the electron microscope, and photography. Prerequisites: admission to the medical or graduate program and permission of instructor.

558. **MEDICAL PARASITOLOGY (2)** Basic information on protozoa, helminths, arthropods, and mollusks involved in the causation of human diseases.

559. **EPIDEMIOLOGY (2)** Provides information on epidemiology—the study of factors that affect occurrence and course of disease in a population.

572. **LITERATURE REPORTS (1 per term)** Weekly analysis of current literature in microbiology.

590. **COLLOQUIUM (1-3)**

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

MINERAL ECONOMICS (MN EC)

WILLIAM A. VOGELY, *Head of the Department*
104 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Gordon, Schenck, Tilton, and Vogely.

Graduate Faculty: Associate Member Sani.

The program in mineral economics prepares students for careers in mineral industries management, administration, or economic analysis and planning. Students may specialize in such areas as commodity analysis (energy, metals, or nonmetals); resource economics (mineral policy or area studies); industrial economics (administration, market research, or financial matters); geostatistical and economic analysis of exploration and exploitation problems; or operations research and statistics (resource allocation, forecasting, or decision making).

Two related, but distinctly different, general programs for obtaining the M.S. and Ph.D. degrees are available, the one chosen depending on the education and practical experience of the candidate. One program is for students whose background is in the mineral industries and who wish to combine their scientific training with an understanding in depth of the methods by which economics can aid in solving problems in mineral industries exploration, exploitation, and processing. Requirements for admission to this program are 24 credits in chemistry, physics, mathematics, or statistics; 12 in the earth sciences; 9 in economics, mineral economics, commerce, business administration, or industrial management; and 6 in engineering subjects.

The second program is for students whose background is in economics and whose training and experience have given them an interest in applying their economic skills to the solution of mineral industries problems. Requirements for admission to this program are 12 credits in economics, mineral economics, and business administration; 6 in geological sciences; and 9 in mathematics and statistics.

The differences between the programs followed by these two groups of students will affect many aspects of their graduate programs — thesis work, required mineral economics courses, and elective selection. In all cases, the choices among courses and the emphasis within courses taken would be determined by the background of the student. The mineral-industries-based program places equal emphasis on the technical and economic aspects of mineral economics, and the economics-based

program places more emphasis on the economic than on the technical features of the problems considered.

In addition to the normal degree requirements of the Graduate School, candidates for the M.S. degree must write a thesis and defend it orally. Doctoral candidates in the mineral-industries-based program must complete at least 15 credits in economics (including courses used for admission). M.S. students in both programs are also required to take 9-12 credits in statistics and computer science either before admission or as courses taken in addition to the minimum required for the M.S. degree. Doctoral candidates in the economics-based program must complete at least 12 credits in the earth sciences or mineral engineering. The candidacy examination for the doctorate is oral, and the oral examination for the M.S. degree at The Pennsylvania State University may be used as the candidacy examination for the doctorate. If this is done, the M.S. examination will be more detailed and broader in scope than it would be for the M.S. alone. The comprehensive examination for the doctorate includes written examinations in the major program and minor fields in addition to the oral examination required by the Graduate School. The communication requirement is satisfied by departmentally approved courses in mathematical statistics and mathematics. There is no foreign language requirement.

Students with deficiencies of 9 credits or fewer in either program may be admitted as degree candidates but will be required to make up such deficiencies without these credits being applicable toward the advanced degree. Students with a 2.75 junior-senior average, above-average scores on the Graduate Record Examination Aptitude Test, and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

MINERAL ECONOMICS (MN EC)

- 453. NONMETALLIC MINERALS (3)
- 483. ECONOMICS OF THE METALS INDUSTRIES (3)
- 484. POLITICAL ECONOMY OF ENERGY AND THE ENVIRONMENT (3)
- 490. MINERAL VALUATION (3)
- 495. MINERAL INDUSTRIES DECISION MAKING (3)

- 500. ADVANCED READINGS IN MINERAL ECONOMICS (3) Selected readings on topics in mineral history, mineral economics research, applications of economic theory, mineral policy and law, and mineral exploration.
- 504. ADVANCED PRINCIPLES OF MINERAL ECONOMICS (3) Minerals as capital — taxation, conservation, and land tenure; operations of mineral markets; government policy; minerals in world trade and development.
- 506. ADVANCED STUDIES IN MINERAL COMMODITIES (3) Economic studies of selected mineral commodities and their products.
- 509. (Geol. 509) GEOLOGY AND ECONOMICS OF THE CONSTRUCTION MATERIALS (3) Occurrence, origin, and marketing of the mineral materials used by the construction industry. Economic and geologic evaluation of actual deposits.
- 510. (Geol. 510) GEOLOGY AND ECONOMICS OF THE INDUSTRIAL MATERIALS (3) Occurrence, origin, and marketing of the industrial minerals and evaluation of deposits. Chemical and ceramic raw materials emphasized.
- 513. APPRAISAL OF MINERAL RESOURCES AND ANALYSIS OF EXPLORATION DECISIONS (3) Mineral resource concepts; various quantitative methods for resource evaluation, including computer simulation; exploration economics and decision making within quantitative frameworks. Prerequisite: Mn.Ec. 490.
- 519. (Econ. 519) MINERAL POLICY ANALYSIS (3) Principles of policy analysis; cost-benefit and other analytical techniques; environmental analyses; case studies of legislative and administrative mineral policy issues.

524. THE ECONOMIC ANALYSIS OF ENERGY MARKETS (3) Unified theory of exploration, development, and production; its application; domestic and foreign public policies; new sources; forecasting. Prerequisite: Econ. 302.

529. MINERAL INVESTMENT VALUATION (3) Investment analysis for mineral properties; including reserve estimation, capital budgeting techniques under risk, taxation, capital cost, and selected investment decisions.

530. CONTEMPORARY ISSUES IN MINERAL FINANCE (3) Critical investigation of current problems in mineral finance, including the issues of capital availability, and domestic and foreign mineral investment. Prerequisite: Mn.Ec. 490 or Fin. 405.

590. COLLOQUIUM (1-3)

593. TECHNICAL PROBLEMS IN MINERAL ECONOMICS (1-12) Individual research involving library, laboratory, or field work designed to provide solutions to a selected technoeconomic problem in mineral industries. Prerequisites: Mn.Ec. 500, 504.

MINERAL ENGINEERING MANAGEMENT (M E M)

R. V. RAMANI, *Section Chairman of Mineral Engineering Management*
118 Steidle Building

Degree Conferred: M.Eng.

Graduate Faculty: Senior Members Aplan, Farouq Ali, Given, Hummel, Lovell, Manula, W. Miller, Niebel, Ramani, Rosenshine, Saperstein, Schenck, Stahl, and Stefanko.

Graduate Faculty: Associate Members Guild and Morley.

This program is designed to educate engineers for advancement into executive production management positions in the mineral and heavy construction industries, in development and sales in manufacturing companies, and in consulting firms. Its aim is to provide the knowledge, skills, and attitudes needed by persons to become innovators and responsible decision-making leaders. Participants are trained to create new designs, systems, and methods, and to plan, develop, and lead mineral industry organizations.

The content of appropriate courses is based upon specific problems encountered in the mineral industries. Such courses are offered by the departments which have combined their resources to offer this interdisciplinary effort: the Departments of Mineral Engineering (Mining and Petroleum and Natural Gas sections), Mineral Economics, Materials Science and Engineering, and Industrial and Management Systems Engineering. Courses in these areas and others may be selected by students and adapted to their individual interests.

The program emphasizes quantitative methods, principles of economics applied in mineral industries, and management.

Students are required to present a scholarly written report on a suitable project, the topic of which may be suggested by industry.

For admission a bachelor's degree in one of six engineering branches of mineral industry (mining, petroleum, mineral processing, metallurgy, fuel, and ceramics) or some other closely related field (industrial, civil, geological, mechanical, or chemical engineering) is required. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MINERAL ENGINEERING MANAGEMENT (M E M)

510. PRODUCTION AND OPERATIONS MANAGEMENT (3-9) Overall planning, design, and selection of equipment; programming and scheduling of mineral operations; statistical control of costs and production indices.

MINERAL PROCESSING (MN PR)

LEONARD G. AUSTIN, *In Charge of Graduate Programs in Mineral Processing*
108 Steidle Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aplan, Austin, Hogg, and Lovell.

Graduate Faculty: Associate Members Luckie and Osseo-Asare.

This program is one of the options in which a graduate student in the Department of Mineral Engineering can receive an advanced degree. After ores and minerals are mined, they are usually processed to concentrate valuable components or remove undesirable components; then they are converted into useful products. The process engineering involves large plants which treat millions of tons of material per year at low cost, and is essential to such important industries as coal, power generation, steel, nonferrous metals, heavy chemicals, cement, and nonmetallic minerals. The world is facing shortages of energy, water, and raw materials, and the mineral processing engineering profession will play a key role in reducing and solving these problems. Increased efficiency and new ideas are urgently needed.

The training of a mineral processing engineer involves interdisciplinary combinations of chemistry, physics, the geological sciences, and engineering. This knowledge is then integrated with specialized knowledge — the creation, characterization, separation, agglomeration, and handling of mineral particles; the flotation and surface chemistry of mineral particles; and chemical extractions and separations — to provide the basis for developing and understanding the practical means of removal of valuable material from the rock body.

Pollution control is an important aspect of mineral processing because of the problems of disposal of large quantities of waste produced by the mining, metallurgical, cement, power, and heavy chemical industries, and the volume of process water used by these industries. Many air and water pollution control methods use equipment and processes originally developed for minerals treatment. Mineral processing methods are involved in the recycling and reuse of metals and other materials. A student may emphasize pollution control through course work and thesis research. The section also cooperates in the all-University interdisciplinary program leading to the Master of Science in environmental pollution control or the Master of Environmental Pollution Control.

The program of study for each student is decided by a study panel consisting of three faculty members and the student. The communication and foreign language requirement for the Ph.D. degree may be satisfied by reading proficiency in one foreign language. Students whose first language is English must demonstrate proficiency in German, Russian, or Japanese (or other language in which a major body of relevant technical literature exists). Students whose first language is not English will be required to show fluency in reading, speaking, comprehending, and writing English and may in some cases be required to demonstrate proficiency in one other approved language.

Graduates with bachelor's degrees in engineering, chemistry, chemical engineering, materials (ceramics, metallurgy), fuels, geological sciences, mathematics, mining, or physics are eligible for admission. Students with deficiencies may be required to make them up concurrently with their graduate studies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds (such as industrial experience), abilities, and interests.

The following courses listed elsewhere are appropriate for Mineral Processing students: Mat.Sc. 411, 420; Metal. 401, 404, 414, 426.

MINERAL PROCESSING (MN PR)

- 401. MINERAL PROCESS ENGINEERING (3)
- 413. MINERAL PROCESSING LABORATORY (1)
- 421. PARTICLE TECHNOLOGY LABORATORY (1-3)
- 424. COAL PREPARATION (3)
- 425. INTERFACIAL PHENOMENON AND FLOTATION (3)
- 427. POLLUTION CONTROL IN THE MINERAL PROCESS INDUSTRIES (3)

- 501. INTERFACIAL PHENOMENA IN MINERAL SYSTEMS (3) Applications of surface phenomena to mineral engineering systems. Thermodynamics of surfaces, flotation, adsorption of detergents, electrical double layer, flocculation, dispersion. Prerequisite: Chem. 451.
- 502. FROTH FLOTATION AND AGGLOMERATION (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 501.
- 505. PHYSICAL SEPARATIONS IN MINERAL PROCESSING (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal, and other methods of mineral processing. Prerequisite: Mn.Pr. 401.
- 506. MINERAL PROCESS PLANT DESIGN (3-10) Process design and economy. Development and quantification of flow sheets. Integration of unit operations. Plant layout, equipment selection, and instrumentation. Prerequisite: Mn.Pr. 401.
- 507. CHEMICAL METHODS IN MINERAL PROCESSING (3) Practice and theory of methods to upgrade ores by chemical treatment including roasting, solubility separations, surface phenomena, and reactions. Prerequisite: Mn.Pr. 401.
- 508. MINERAL PARTICLE SYSTEMS (3) Creation, characterization, separation, and agglomeration of particles. Comminution, sizing, fractionation of powders; surface area, pore size determinations. Agglomeration and balling.
- 509. PARTICLE-FLUID DYNAMICS (3) Movement of particles in fluids, rheology of non-newtonian mineral suspensions, design of concentrating devices, fluidized beds, electrodynamic, magnetic separations.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

MINING ENGINEERING (MNG E)

LEE SAPERSTEIN, *Section Chairman of Mining Engineering*
118 Steidle Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Hardy, Lovell, Manula, Ramani, Saperstein, Stefanko, and Voight.

Graduate Faculty: Associate Member Morley.

Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering (ore estimation, cost analysis and control, budgeting); mechanization and mine plant (unit operations, materials handling, continuous mining, power supply); development and exploitation methods (mine planning and layout, design of systems); mine management, production engineering (work and methods analysis, operations analysis); operations research,

environmental control and health and safety (gas and dust technology, ventilation, air conditioning, hygiene, illumination, noise, safety, mine drainage, land reclamation, waste disposal); and rock mechanics (stress analysis, roof and ground control, penetration, fragmentation, subsidence).

Students who desire to obtain the Master of Engineering degree in mining engineering must take a minimum of 30 credits (including at least 12 credits at the 500 level) of appropriate courses in the major area and elective courses. A scholarly written report is also required. Programs of study are available in general mining engineering, rock mechanics, mine operations, research systems engineering, internal or external mine environmental control, mine health and safety; and emphasis can be given to any of the areas listed above.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by completion of courses in two languages or by completion of courses in one language and 6 credits of computer science. A thesis is required for the M.S. degree.

A bachelor's degree in mining engineering or a related engineering field is required for admission. Students may be required to make up deficiencies in their area of specialization. Certain basic related courses outside the department may be approved as part of the major. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

MINING (MNG)

- 400. MINING AND OUR ENVIRONMENT (3)
- 402. MINE PLANT DESIGN (3)
- 403. MINE POWER SYSTEM AND COMMUNICATION DESIGN (3)
- 410. MINING ENGINEERING ANALYSIS (3)
- 411. MINE SYSTEMS ENGINEERING (3)
- 422. MINE VENTILATION AND AIR CONDITIONING (3)
- 431. ROCK MECHANICS (3)
- 441. SURFACE MINING SYSTEMS AND DESIGN (3)
- 451. ADVANCED MINING ENGINEERING (1-3)

- 513. MINE COST ANALYSIS (3) Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records.
- 514. MINE OPERATIONS ANALYSIS (3) Application of operations research techniques in determining optimal design and operating policies for mine management. Prerequisite: Mng. 411.
- 515. MINE SYSTEMS SIMULATION (3) Principles and practices of probabilistic and deterministic simulation in the analysis of operating systems related to mills and mines. Prerequisites: Cmp.Sc. 401, Mng. 411.
- 531. RHEOLOGICAL AND STRENGTH CHARACTERISTICS OF ROCKS (3) Properties of rocks and their determination; failure theories; brittle to ductile transition; rheological behavior. Prerequisite: Mng. 431.
- 532. SPECIAL TOPICS IN ROCK MECHANICS (1-3) Behavior of rock under static loading; underground stress instrumentation; experimental stress analysis; design of mine openings; theories of subsidence.
- 542. THEORY OF ROCK FRAGMENTATION (3) Behavior of rock under dynamic loads intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E.Mch. 13, Mng. 30, Psy. 203.
- 543. STRATA CONTROL ENGINEERING (3) Theoretical considerations; convergence, abutments, subsidence; rockbursts; underground support systems; design of mine openings. Prerequisite: Mng. 431.

545. **ROCK MECHANICS INSTRUMENTATION (3)** Strain gauge circuitry, transducers, electrohydraulic servo installations, and integrated strain and force measuring systems as applied to rock mechanics. Prerequisite: Mng. 431.

580. **MINING ENGINEERING RESEARCH (1-3 per term)** Supervised research on a specific problem involved in mining science or technology.

590. **COLLOQUIUM (1-3)**

MUSIC (MUSIC)

ROBERT W. BAISLEY, *Head of the Department*
232 Music Building

Degrees Conferred: M.A., M.Mus.

Graduate Faculty: Senior Members Baisley, Brinsmaid, Brown, Fenner, and D. Miller.

Graduate Faculty: Associate Members J. Feldman, L. Feldman, P. J. Miller, and Perison.

The Master of Arts degree is academic in nature, and the program is directed toward musicological research. Admission requires the completion of a recognized music major or its equivalent, and a reading knowledge of one foreign language, either French or German. A thesis is required of all M.A. candidates. While 30 credits are listed as a minimum requirement, it should be noted that the amount of course work necessary may exceed the minimum, according to the needs and background of the student involved.

The Master of Music degree program is planned to provide professional emphasis. Students will specialize in either performance or composition. In addition to credit requirements, admission to the program is contingent upon department certification of the candidate's competence. According to the area of specialization, an audition or submission of manuscripts is required. Arrangements for this can be made by the student with the department. While 48 credits are listed as a minimum requirement, it should be noted that the amount of course work necessary may exceed the minimum according to the needs and background of the student involved.

Students who lack the recommended upper-class courses in music may be required to take additional course work without receiving graduate credit.

The department sponsors musical activities, and candidates for both degrees are required to participate in positions of responsibility. All candidates for degrees are expected to be in residence for a minimum of three consecutive terms.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests. All applicants for graduate degrees must take the Graduate Record Examination, including the Advanced Music Examination.

MUSIC (MUSIC)

410. **MUSIC OF THE TWENTIETH CENTURY (3)**

412. **MUSIC OF THE BAROQUE PERIOD (3)**

413. **MUSIC OF THE MIDDLE AGES (3)**

414. **MUSIC OF THE RENAISSANCE (3)**

417. **MUSIC OF THE CLASSICAL PERIOD (3)**

418. **MUSIC OF THE ROMANTIC PERIOD (3)**

*429. **VOCAL STYLE (3 per term, maximum of 18) Fee \$80.**

*Course may be scheduled only after consultation with the head of the department.

455. FORM AND ANALYSIS (2)
457. COMPOSITION (2 per term, maximum of 16)
459. ORCHESTRATION AND ARRANGING (3)
465. FORM AND ANALYSIS (2)
466. ADVANCED CONDUCTING (2 per term, maximum of 12)
467. OPERA WORKSHOP (1-6)
468. ADVANCED CHAMBER MUSIC (1-6)
470. CONTEMPORARY TECHNIQUES (3)
500. INTRODUCTION TO MUSIC REFERENCE AND RESEARCH MATERIALS (3) A study of musicological reference and research materials in English and western European languages, with exercises in their use.
- *501. ADVANCED HARPSICHORD (3 per term, maximum of 18) Instruction in harpsichord playing; preparation for recital performance. Fee \$100.
- *503. ADVANCED ORCHESTRAL INSTRUMENTS (3 per term, maximum of 18) Study, repertoire building, and recital performance. Fee \$80.
- *511. ADVANCED PIANO (3 per term, maximum of 18) Piano literature of all periods for public performance. Fee \$80.
- *520. VOICE (3 per term, maximum of 18) Study, repertoire building, and recital performance. Fee \$80.
- *531. ADVANCED ORGAN (3 per term, maximum of 18) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee \$100.
555. ANALYTICAL TECHNIQUES (3) Advanced analysis of music of all periods.
- *558. FREE COMPOSITION (3 per term, maximum of 18) Composition: vocal and instrumental, standard or modern idioms.
- *560. ORCHESTRAL AND CHORAL CONDUCTING (3 per term, maximum of 18) Supervised conducting in selected performance situations, rehearsal techniques and comprehensive score analysis.
571. PERFORMANCE PRACTICES (3) Analysis and performance of music of various periods based on manuscripts, documents, and other source materials.
572. SEMINAR IN MUSICOLOGY (3 per term, maximum of 9) Research in selected areas of music history.
580. STUDIES IN ORCHESTRAL LITERATURE (3) Selected studies in orchestral literature from the seventeenth century to the present.
581. STUDIES IN CHAMBER MUSIC LITERATURE (3) Selected studies in chamber music of all types from the seventeenth century to the present.
582. STUDIES IN KEYBOARD LITERATURE (3) The literature of major keyboard instruments from the sixteenth century to the present.
583. STUDIES IN CHORAL LITERATURE (3) Selected studies in choral literature of all types from the Renaissance to the present.
584. STUDIES IN OPERATIC LITERATURE (3) Studies in the development of the opera from 1600 to the present, treating both libretto and music.
585. STUDIES IN VOCAL LITERATURE (3) Selected studies in solo vocal literature of all periods.
589. MUSIC SEMINAR (1-6) Seminar in the history, art, and science of music, with readings, discussion, and performance.

*Course may be scheduled only after consultation with the head of the department.

MUSIC EDUCATION (MU ED)

J. DAVID BOYLE, *In Charge of Graduate Programs in Music Education*
263 Chambers Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Boyle and Deihl.

Graduate Faculty: Associate Members Thompson and Wooderson.

Graduate programs in music education prepare students for careers in public-school music teaching, music supervision, college teaching, administration, or research. It is possible to include study in a number of these areas in the M.Ed. or D.Ed. programs.

Completion of a recognized music education major, or program leading to teaching certification in music, is a prerequisite for admission to the M.Ed. or D.Ed. programs. D.Ed. candidates will spend at least three consecutive terms in residence some time between admission to candidacy and completion of the degree program.

Applicants for the master's program who present a 2.75 junior-senior average and two satisfactory professional references will be considered for admission to the program in music education, provided they have appropriate course backgrounds and musical proficiency.

Admission to the doctoral program requires: a junior-senior minimum average of B; approximately half of any graduate credits of A quality; an interview prior to admission; submission of a satisfactory score on the Graduate Record Examination; five recommendations attesting to scholarship, musicianship, and ability to do independent study; and a minimum of two years of successful teaching experience in public or private schools.

The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

MUSIC EDUCATION (MU ED)

- 415. WORKSHOP IN SELECTED MUSIC EDUCATION STUDIES (1-6)
- 445. METHODS, ELEMENTARY GRADES (3)
- 446. THE ELEMENTARY MUSIC SPECIALIST (3)
- 448. METHODS, JUNIOR AND SENIOR HIGH SCHOOLS (3)
- 449. STUDENT TEACHING IN THE ELEMENTARY SCHOOL (2-6)
- 450. STUDENT TEACHING IN THE HIGH SCHOOL (2-6)
- 454. ORCHESTRA AND BAND METHODS AND MATERIALS (3)
- 455. STUDENT TEACHING IN INSTRUMENTAL MUSIC (2-6)
- 468. THE TEACHING OF PIANO (3)
- 469. BAND AND ORCHESTRA TECHNIQUES (3)
- 471. TEACHING MARCHING BAND (3)
- 472. WIND INSTRUMENT MATERIALS (3)
- 473. PSYCHOLOGICAL FOUNDATIONS OF MUSICAL BEHAVIOR (3)
- 474. SELECTING AND DEVELOPING MEASURES OF MUSICAL BEHAVIOR (3)
- 480. CHORAL PROGRAM IN THE SECONDARY SCHOOL (3)
- 487. CHILDREN'S SONGS AND RECORDS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501. PROBLEMS AND PROJECTS IN MUSIC EDUCATION (1-6) Independent work on special topics of music education pertinent to the development of curricula, methods, and materials in music education. Prerequisite: 12 graduate credits in education (including music education).

525. PROSEMINAR: GRADUATE STUDY IN MUSIC EDUCATION (1-3) Bibliography; location and evaluation of reference materials; organization, form, style in preparing music education research reports and other papers.

555. **RESEARCH METHODS IN MUSIC EDUCATION (3-6)** Research methods and designs for problems in music education; techniques for studying cognitive, affective, and psychomotor responses to musical stimuli. Prerequisites: Mu.Ed. 525; Ed.Psy. 475; Ed.Psy. 406 or 407.
569. **TRENDS IN INSTRUMENTAL MUSIC (3-6)** Methods and materials for school instrumental ensembles.
570. **CHORAL TECHNIQUE (3-6)** Analysis and evaluation of choral materials appropriate for secondary school chorus; program building; practical rehearsal and conducting techniques. Prerequisite: 6 credits of vocal study.
572. **INSTRUMENTAL PEDAGOGY (1-6)** Independent work on special problems in instrumental music pedagogy. Prerequisite: practical experience and 10 graduate credits in music and/or music education.
573. **THE MATERIALS OF APPRECIATION (3)** Examination of written and recorded materials and appropriate techniques for developing appreciation of music at elementary, secondary, and college levels.
574. **CONTEMPORARY MUSIC CURRICULA IN THE ELEMENTARY SCHOOL (3)** Developing music curricula for the elementary school incorporating current theories, practices, materials and research data.
575. **CONTEMPORARY MUSIC CURRICULA IN MIDDLE AND JUNIOR HIGH SCHOOLS (3)** Instructional materials, procedures, and curricular activities, integration with other subjects.
576. **MUSIC SUPERVISION (3)** Current educational procedures in training music supervisors.
577. **INTERNSHIP IN MUSIC SUPERVISION (3-6)** Internship in schools under supervision of graduate faculty in music education. Prerequisites: C.&S. 581, Mu.Ed. 576.
581. **CONTEMPORARY MUSIC EDUCATION (3)** Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.
590. **COLLOQUIUM (1-3)**
591. **INTERNSHIP IN MUSIC PERFORMANCE TECHNIQUES (1-6)** Internship in selected school or music performance situations other than those in the district where the graduate student is employed.
594. **PEDAGOGY OF MUSIC THEORY, READING, AND EAR TRAINING (3)** Instructional theory and materials basic to teaching music theory, reading, and ear training. Musical instruments, audio-visual devices as aids. Prerequisite: 12 credits in music theory and/or harmony.

NUCLEAR ENGINEERING (NUC E)

WARREN F. WITZIG, *Head of the Department*
231 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Diethorn, Foderaro, Jacobs, Jester, Kenney, Klevans, Levine, Palladino, Pillay, Remick, Schultz, and Witzig.

Graduate Faculty: Associate Member Robinson.

Programs of study are individually tailored, and engineering is emphasized through the study of reactor principles — computational methods, transport theory, and nuclear design; plasma principles — waves, analysis, and fusion laboratory; shielding — Monte Carlo methods and two-body kinematics; reactor systems design — thermal, mechanical, and control; reactor fuels — configuration, radiation effects, and fuel cycle management; isotope utilization — activation analysis, chemical processes including nuclear medicine; safety analysis — reactor siting, engineered safeguards, and environmental effects. The department offers three degrees at the master's level: M.Eng., M.S. with paper, and

M.S. with thesis. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language and proficiency in English.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

NUCLEAR ENGINEERING (NUC E)

- 401. INTRODUCTION TO NUCLEAR ENGINEERING (3)
- 402. NUCLEAR REACTOR DYNAMICS DESIGN (3)
- 405. APPLIED NUCLEAR AND RADIOCHEMISTRY (3)
- 408. RADIATION SHIELDING (3)
- 410-411. NUCLEAR REACTOR THEORY (3 each)
- 415. RADIONUCLEAR APPLICATIONS (3)
- 420. RADIOLOGICAL SAFETY (3)
- 425. (Bio.E. 425) RADIOGRAPHIC IMAGING (3)
- 428. RADIOACTIVE WASTE CONTROL (3)
- 430. DESIGN PRINCIPLES OF REACTOR SYSTEMS (3)
- 431. SYNTHESIS OF NUCLEAR SYSTEMS (3)
- 440. NUCLEAR ENGINEERING LABORATORY I (3)
- 441. NUCLEAR ENGINEERING LABORATORY II (3)
- 444. NUCLEAR REACTOR OPERATIONS LABORATORY (1)
- 490. (E.E. 490) INTRODUCTION TO PLASMAS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501. REACTOR ENGINEERING (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: M.E. 412 or Nuc.E. 430; Nuc.E. 411.

502. REACTOR ENGINEERING LABORATORY (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 411 (only if more than 1 credit of Nuc.E. 502 is taken).

503. THERMONUCLEAR ENGINEERING (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math. 452.

505. REACTOR INSTRUMENTATION AND CONTROL (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.

506. TWO-BODY KINEMATICS (3) Conservation laws of classical and quantum mechanics and their application to interactions between two bodies. Prerequisite: Math. 72.

507. INTERACTION OF RADIATIONS WITH MATTER (3) Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. Prerequisite: Nuc.E. 506.

509. RADIATION DAMAGE IN SOLIDS (2) Production of defects by high-energy particles; nature of defects; diffusion and annealing in solids; macro property changes. Prerequisite: Nuc.E. 507.

511. NUCLEAR REACTOR MATERIALS (3) Philosophy, selection, technology, use, economics, and performance of materials of major interest in nuclear power reactors today. Prerequisite: Nuc.E. 411.

512. NUCLEAR FUEL MANAGEMENT (3) Nuclear fuel inventory determination and economic value through the fuel cycle. Emphasis on calculational techniques in reactor, optimization, and design. Prerequisite: Nuc.E. 411.

520. REACTOR ANALYSIS (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.

521. NEUTRON TRANSPORT THEORY (3) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.

540. (E.E. 540) THEORY OF PLASMA WAVES (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: Nuc.E. 490.

541. (E.E. 541) PLASMA THEORY (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: Nuc.E. 540 (E.E. 540).

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

NURSING (NURS)

MARGARET A. NEWMAN, *In Charge of Graduate Program in Nursing*
15 Henderson Human Development Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members Baltes, Gunter, and Newman.

Graduate Faculty: Associate Members Banghart, Laubach, Mandrillo, Metzger, O'Brien, Rinehart, Suman, Taheri, Therrien, Waters, and Williamson.

The master of science degree in nursing is offered in recognition of the completion of a program which emphasizes productive scholarship and research in the preparation of the advanced nursing practitioner. The program is accredited by the National League for Nursing (NLN).

Each student must earn a minimum of 40 graduate credits with at least 30 earned as approved resident credits. A core of 9 credits in nursing theory, research, and models of practice is required of all students. Students may select an area of specialization in nursing practice for 21-25 credits) including electives), from among family health, community mental health, adult health and aging, and transcultural health. Additionally, 6-10 credits are required for statistics and thesis work. Each student must successfully pass a comprehensive examination.

Applicants should hold a baccalaureate degree in nursing from an NLN-accredited program or its equivalent. (Students with degrees from non-NLN-accredited programs will be evaluated by the admissions committee in the department on an individual basis.) Students judged to have deficiencies may be eligible for admission with the understanding that all deficiencies must be completed. An overall grade-point average of 3.0 on a 4.0 scale is expected for undergraduate work. A course in basic statistics is required.

NURSING (NURS)

405. OCCUPATIONAL HEALTH NURSING (3)

410. NURSING CARE OF THE FAMILY IN THE COMMUNITY (3)

425. SCHOOL HEALTH NURSING (3)

445. TRAUMA NURSING (3)

450. REHABILITATION NURSING (3)

455. ADVANCED MEDICAL NURSING (3)

460. ADVANCED SURGICAL NURSING (3)

486. INTRODUCTION TO NURSING SERVICE ADMINISTRATION (2)

490. NURSING STUDY IN SPECIALIZED SETTING (1-12)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

501. ISSUES IN NURSING AND HEALTH CARE (2) Consideration of personal, social, political,

economic, philosophical, ethical problems/questions and ways of confronting and resolving conflicts in professional practice.

511. **DESIGN AND ANALYSIS OF CLINICAL STUDIES IN NURSING (3)** Research design for problems of developing and evaluating nursing care programs, products, methods and procedures. Prerequisite: Stat. 200 or courses to provide fundamental knowledge of statistics.

515. **THE NURSE ADMINISTRATOR (3)** Current theories, emerging roles and issues related to the administration of nursing in a variety of settings.

518. **THE NURSE EDUCATOR (3)** Exploration of educational process in nursing including policy making, constraints, educational patterns, and emerging trends and issues.

520. **BASIC PRINCIPLES OF PHYSICAL ASSESSMENT (5)** Basic knowledge and skills of physical assessment and related physiology and certain laboratory techniques.

521. **BASIC PSYCHOSOCIAL PRINCIPLES IN HEALTH ASSESSMENT (3)** Basic principles of health interviewing; utilization of knowledge of social sciences as basis for psychosocial aspects of health assessment. Prerequisite: 9 credits in psychology and/or sociology.

522. **MEDICATION MANAGEMENT (3)** Therapeutic health maintenance principles based upon clinical pharmacology; drug therapy; management; drug metabolism, interaction, side effects, toxic effects, patient teaching. Prerequisite: basic background in principles of pharmacology.

530. **CLINICAL PROCESS IN HEALTH CARE AND NURSING (3-10)** Supervised experience to develop competence in selected clinical or functional areas of health care or nursing practice. Prerequisite: completion of advanced nursing theory courses in selected clinical or functional areas, or permission of instructor.

550. **TRANSCULTURAL HEALTH NURSING (3)** Theoretical background for design, implementation, evaluation of nursing care to promote, maintain, and restore health, congruent with cultural patterns.

590. **COLLOQUIUM (1-3)**

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

NUTRITION (NUTR)

MICHAEL H. GREEN, *In Charge of Graduate Programs in Nutrition*
202 Henderson Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.; M.S. in Nutrition in Public Health

Graduate Faculty: Senior Members Guthrie, Shannon, Underwood, Wolinsky, and Wright.

Graduate Faculty: Associate Members Green, Massaro, and Sims.

Graduate programs in nutrition prepare students for careers in college teaching, research, industry, and government. The program in nutrition in public health prepares the student for work in public health and community agencies.

To satisfy the communication and foreign language requirement for the Ph.D. degree, students are expected to demonstrate competence in technical writing (Engl. 418) and spoken English.

For admission to a graduate program in nutrition, a student must have completed at least 6 credits in inorganic and organic chemistry, 3 each in biochemistry, microbiology, and human physiology, 4 in other physical and biological sciences, and 8 in foods and/or nutrition. For admission to the program in nutrition in public health, an additional 12 credits in social sciences are required.

Students with a 2.80 junior-senior average, appropriate course backgrounds, and an acceptable score

on the Graduate Record Examination (GRE) or Miller Analogies Test (MAT) will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Students with up to 8 credits of deficiency may also be admitted. Any deficiencies must be completed with a grade of B within two terms.

For other graduate courses in nutrition see A.Ntr. 501, Energy Metabolism, and A.Ntr. 503, Micronutrients: Nutrition, Metabolism, and Function. Current topics are presented as announced in Nutr. 597.

NUTRITION (NUTR)

- 400. INTRODUCTION TO NUTRITION COUNSELING (1-3)
- 420. EXPERIMENTAL FOODS (4)
- 421. CULTURAL ASPECTS OF FOODS (3)
- 422. ADVANCED FOODS (3)
- 452. NUTRITIONAL ASPECTS OF DISEASE (3)
- 453. DIET THERAPY (2)
- 454. LABORATORY METHODS IN NUTRITION (2)
- 456. COMMUNITY NUTRITION (3)
- 457. PRINCIPLES OF HUMAN NUTRITION (3)
- 458. APPLIED HUMAN NUTRITION (2)
- 459. ADVANCED NUTRITION (3)
- 490. FOODS AND NUTRITION SEMINAR (1)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 520. READINGS IN APPLIED NUTRITION (2) Critical review and reports of literature on selected topics in applied nutrition.
- 522. ADVANCED EXPERIMENTAL FOODS (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation.
- 530. PROBLEMS IN FOODS AND NUTRITION (1-6)
- 550. READINGS IN NUTRITION (3) Readings and reports of selected topics in nutrition.
- 551. SEMINAR IN NUTRITION (1-6) Selected topics and recent advances in nutrition.
- 552. NUTRITION IN DISEASE (2) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy.
- 555. FIELD WORK IN NUTRITION (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged.
- 556. THE SURVEY METHOD IN FOODS AND NUTRITION (2) Study of survey techniques as a tool in the assay of food adequacy and nutritional status.
- 557. INTERRELATIONSHIPS OF NUTRIENTS (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition.
- 558. PROTEIN NUTRITION (2) Classical concepts, recent developments and applied aspects of protein and amino acid nutrition and metabolism. Prerequisite: graduate standing in nutrition or related field.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2)

OPERATIONS RESEARCH (OR)

M. C. HALLBERG, *Chairman of the Committee on Operations Research*
101 Weaver Building

Degrees Conferred: Students electing this option through participating graduate programs will earn a degree with a dual title at both the Ph.D. and the M.S. or M.A. levels, i.e., Ph.D. in (graduate program name) and Operations Research, or M.S. or M.A. in (graduate program name) and Operations Research.

Graduate Faculty: Senior Members Aggarwal, Antle, L. Austin, K. W. Crowley, Dinkel, Farouq Ali, Fishburn, Gordon, Gould, Haight, Hallberg, Harkness, Hayya, Heitmann, Hottenstein, Hu, Ignizio, Kleindorfer, C. G. Knight, Kochenberger, J. Lewis, Mann, Manula, McMurtry, J. Nelson, Ramani, Raphael, Rigby, Rosenshine, Sauerlender, Shilling, Tilton, Turner, Willenbrock, and A. V. Williams.

Graduate Faculty: Associate Members Beierlein, Chan, Coelen, Dani, Enscoore, Ferrar, Guild, Haessel, D. B. Johnson, Kibler, Parsons, T. A. Ryan, H. R. Thomas, and Zindler.

The operations research dual-title degree program option is administered by an Operations Research Committee, which is responsible for management of the program. The committee maintains program definition, identifies faculty and courses appropriate to the option, and recommends policy and procedures for its operation to the dean of the Graduate School. This dual-title degree program is offered as an option through graduate major programs in eight Colleges. The option enables students from diverse graduate programs to attain and be identified with the tools, techniques, and methodology of operations research, while maintaining a close association with areas of application. Operations research is the analysis — usually involving mathematical treatment — of a process, problem, or operation to determine its purpose and effectiveness and to gain maximum efficiency. To pursue a dual-title degree under this program option the student must apply to the Graduate School and register through one of the following graduate major programs: agricultural economics, business administration, civil engineering, computer science, economics, educational administration, electrical engineering, forest resources, geochemistry and mineralogy, geography, industrial engineering, man-environment relations, mathematics, mineral economics, mining engineering, petroleum and natural gas engineering, and statistics.

For the Ph.D. degree with operations research option, in addition to those prescribed by the graduate major program, prerequisites for acceptance to the program without deficiency include the following or their equivalent: Math. 61, 62, 63, 71, and 72 or 100; Cmp.Sc. 101; and 6 credits in elementary or introductory micro- or macroeconomics. There are no prerequisites for admission to the M.S. or M.A. program option other than those that may be imposed by the participating graduate major programs.

To qualify for a dual-title degree after admission to the program option, students must satisfy the requirements of the graduate major programs in which they are registered, in addition to the minimum requirements, or their equivalent, in the operations research option.

The minimum requirements for the Ph.D. degree with operations research option are: (1) Mathematics — 9 credits minimum including real analysis (Math. 420) and linear algebra (Math. 441); (2) Statistics — 9 credits minimum with a 6-credit sequence in mathematical statistics (Stat. 409, 410) or in experimental statistics (Stat. 401, 402) and 3 credits in stochastic processes (Stat. 427); (3) Optimization — 12 credits minimum including linear programming I and II, mathematical programming I, and dynamic programming; (4) Processes — 9 credits minimum including inventory models, scheduling models, and waiting line models; (5) Computer Science — 6 credits minimum including numerical methods and digital simulation techniques; and (6) Open Areas (application and/or specialization) — 15 credits minimum.

For the M.S. or M.A. degree with operations research option, 18 credits are required from the areas of statistical methods, computer science, optimization (survey-level courses acceptable), processes (survey-level courses acceptable), and applications. (Application courses are those that involve problem solving through the use of decision methods.) At least 3 credits must be selected from each area. Particular courses may satisfy both the graduate major program requirements and those in the operations research option. A thesis may be required, the supervisor of which must be a member of the Graduate Faculty recommended by the chairman of the program granting the degree and approved by the Operations Research Committee as qualified to supervise thesis work in operations research. A paper or report may be written in lieu of the M.S. or M.A. thesis upon approval of the student's

graduate major program. A student selecting the paper or report must take an additional 6 credits in the operations research program. It is the prerogative of the graduate major program to assign these credits to one or more of the following categories: statistical methods, computer science, optimization, processes, and applications.

A Ph.D. minor program in operations research is available for doctoral students in graduate programs who find it advantageous to include advanced quantitative methods of systems analysis in their program of study and have been approved to do so by their doctoral committee. To qualify for a minor in operations research, students must satisfy the requirements of their graduate major program and take at least 15 credits from the following areas: statistical methods or mathematical statistics, computer science, optimization, and processes. At least 3 credits must be taken from each of optimization and processes areas as listed below.

The doctoral committee is recommended by the graduate major program granting the degree. The chairman and at least two members of a doctoral committee must be members of the Graduate Faculty and approved by the Operations Research Committee as qualified to supervise doctoral theses in operations research. The Operations Research Committee is responsible for administering an examination in operations research which constitutes a portion of the comprehensive examination administered to the doctoral student in the program option, as well as to the candidate who chooses operations research as a minor field.

Courses of a like nature identified as the core of the program option have been given generic names and descriptions. Each such listing may be satisfied by one of the courses given under it.

OPTIMIZATION AREA

Linear Programming I An introduction to the theory and methodology of linear programming.

I.E. 405

Q.B.A. 451

Linear Programming II A further treatment of the theory and methodology of linear programming with emphasis on special formulations.

I.E. 510

Mathematical Programming I Introduction to optimization theory designed to provide the necessary fundamentals for nonlinear programming and more advanced studies in mathematical programming.

Q.B.A. 452

Mathematical Programming II An in-depth treatment of nonlinear programming and geometric programming with emphasis on both theory and applications.

Q.B.A. 550

Mathematical Programming III A seminar dealing with recent advances in mathematical programming.

Q.B.A. 550

Dynamic Programming Study of the concepts underlying model building and optimization of dynamic systems, with applications to engineering, economic, and environmental systems.

I.E. 519

Stat. 534 (M.E.R. 534)

Goal Programming Study of concepts and methods in analysis of systems involving multiple objectives, with applications to engineering, economic, and environmental systems.

I.E. 520

PROCESSES AREA

Inventory Models A study of inventory theory, deterministic and probabilistic models, single and multiproduct models in single- and multistage processes.

I.E. 508

Mgmt. 518

Scheduling Models Scheduling models with simultaneous job arrival and probabilistic job arrival, network scheduling and scheduling simulation techniques.

I.E. 507

Mgmt. 516

Waiting Line Models Theory of systems involving stochastic delay and stochastic service.

I.E. 509

Stat. 528

OPERATIONS RESEARCH (O R)

590. COLLOQUIUM (1 per term, maximum of 3)

PETROLEUM AND NATURAL GAS ENGINEERING (PNG E)

C. DREW STAHL, *Section Chairman of Petroleum and Natural Gas Engineering*
25 Steidle Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Burcik, Farouq Ali, and Stahl.

Graduate Faculty: Associate Member Jacoby.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students who expect to enter graduate study in this program with a degree in another major should present 6 credits in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission. Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

PETROLEUM AND NATURAL GAS (P N G)

400. THESIS (1-6)

410. APPLIED RESERVOIR ENGINEERING (3)

420. APPLIED RESERVOIR ANALYSIS (3)

421. RESERVOIR ENGINEERING (3)

430. RESERVOIR MODELING (3)

440. FORMATION EVALUATION (3)

450. DRILLING DESIGN AND PRODUCTION ENGINEERING (3)

475. PETROLEUM ENGINEERING DESIGN (3)

480. PRODUCTION PROCESS ENGINEERING (3)

481. NATURAL GAS AND GASOLINE PLANTS (2)

485. ENGINEERING IN SECONDARY RECOVERY (3)

486. TERTIARY OIL RECOVERY METHODS (3)

493. ENGINEERING EVALUATION OF OIL AND GAS PROPERTIES (3)

510. SOLUTION OF THE PARTIAL DIFFERENTIAL EQUATIONS OF FLOW IN POROUS MEDIA (3) The application of mathematical techniques to solve the partial differential equations of steady and unsteady state flow in porous media. Prerequisite: Math. 405.

511. NUMERICAL SOLUTION OF THE PARTIAL DIFFERENTIAL EQUATIONS OF FLOW IN POROUS MEDIA (3) Differencing schemes for the partial differential equations of single-phase flow; application to flow of gas and mixing in porous media.

512. NUMERICAL RESERVOIR SIMULATION (3) Mathematical analysis of complex reservoir behavior and combination drives; numerical methods for the solution of behavior equations; recent developments. Prerequisite: P.N.G. 510.

513. ADVANCED NUMERICAL RESERVOIR SIMULATION (3) Compositional simulation; history-matching theory; simulation of basic processes involving heat and mass transfer in porous media. Prerequisite: P.N.G. 512.

514. OPTIMIZATION OF PETROLEUM RECOVERY PROCESSES (3) Optimum search methods, linear programming, nonlinear programming, dynamic programming, application to water-flooding, depletion drive, steam injection, gas cycling, miscible displacement. Prerequisite: P.N.G. 410.

515. ADVANCED OIL RECOVERY TECHNIQUES (3) Advanced oil recovery techniques including water-flooding, in situ combustion, steam injection, hot-water injection, and miscible-phase displacement.

519. DESIGN OF THERMAL RECOVERY PROJECTS (3) Suitability of reservoirs for thermal oil recovery; case histories; design of in situ combustion and steamfloods; thermal stimulation; shale oil recovery. Prerequisite: P.N.G. 515.

520. PHASE RELATIONS IN RESERVOIR ENGINEERING (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.

530. NATURAL GAS ENGINEERING (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycle; current developments. Prerequisite: P.N.G. 481.

550. ADVANCED ENGINEERING EVALUATION OF OIL- AND GAS-PRODUCING PROPERTIES (3) Selected topics of current research and development interest in formation evaluation, geophysical well logging and production economics. Prerequisites: P.N.G. 440, 493.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

NOTE: Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under Materials Science.

PHARMACOLOGY (PHARM)

ELLIOT S. VESELL, *Chairman of the Department*
The Milton S. Hershey Medical Center
Hershey, PA 17033

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Berlin, Beyer, Connor, Fritz, Greene, Hayes, Jacob, Severs, and Vesell.

Graduate Faculty: Associate Members Dvorchik, Liu, Lloyd, Passananti, Schneck, and Smith.

The graduate studies program in pharmacology is designed to give qualified students a combination of didactic instruction, informal direction, and laboratory experience which will enable them to obtain a firm foundation in the principles, methods, and contributions of pharmacology (defined broadly as the science of the multiple aspects of the interaction of chemical agents with biological systems). With this preparation, graduates of the program should be capable of designing and executing high-quality independent research, and of assuming positions of responsibility within the pharmacologic community.

The department offers studies in the general areas of drug metabolism, molecular pharmacology, endocrine pharmacology, neuropharmacology, cardiovascular-renal pharmacology, and clinical pharmacology. Primary emphasis is placed on the molecular mechanism by which drugs act in the body and by which the body transforms drugs.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required; reading knowledge of one or two foreign languages is recommended. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Two letters of recommendation are required, along with a curriculum vitae and Graduate Record Examination scores.

This program is offered only at The Milton S. Hershey Medical Center.

PHARMACOLOGY (PHARM)

501. PHARMACOLOGY (4) Lectures, discussions, and laboratory study of the mechanism of drug action in biological systems.

502. PHARMACOLOGY (4) Continuation of Pharm. 501.

504. DRUG METABOLISM (3) Study of chemical transformation of drugs within animal cells and drug-metabolizing enzymes present in liver microsomes performing this function. Prerequisite: Pharm. 501.

505. PHARMACOKINETICS (3) Quantitation of the time courses of absorption, distribution, metabolism and excretion of drugs in the intact organism. Prerequisites: Pharm. 501, 502, or 520.

510. MOLECULAR TURNOVER IN ANIMALS (3) In-depth consideration of the dynamic state of body constituents as applied to carbohydrates, lipids, nucleic acids, and particularly to proteins. Prerequisite: Bchem. 502.

511. MOLECULAR MECHANISM OF ACTION OF DRUGS (2) Series of lectures and informal discussion on the molecular mechanism of action of some drugs and their clinical applications. Prerequisite: Bchem. 502.

512. CLINICAL PHARMACOLOGY (3) Drug therapy of cardiovascular, renal, and neural diseases.

515. HUMAN GENETICS (2) Seminar-type presentations by students and staff on fundamental problems and current topics in human genetics.

520. PRINCIPLES OF DRUG ACTION (2) Detailed analysis of basic parameters governing drug actions.

525. PHARMACOLOGY OF ANTITUMOR DRUGS (2) Study of the mechanisms of antitumor drug action in biological systems. Prerequisite: Pharm. 501.

530. PHARMACOLOGY OF PSYCHOTROPIC DRUGS (2) Systematic analysis of the effects of psychotropic drugs.

540. PHARMACOGENETICS (3) Study of human responses to individual drugs.

549. NEURAL SUBSTRATES FOR DRUG ACTION (2) Correlation of the sites of action within the central nervous system where certain common drugs exert major effects. Prerequisites: Pharm. 501, 502.

550. NEUROPHARMACOLOGY (2) Study of mechanisms of action of drugs which alter neuronal transmission in the peripheral and central nervous systems.

571. **TECHNIQUES IN PHARMACOLOGICAL RESEARCH (2)** Classes will be comprised of lectures by the faculty of the Department of Pharmacology, followed by working demonstrations of the techniques.

575. **DEVELOPMENT OF RENAL DRUGS (3)** The development and clinical application of new therapeutic agents, using one or more prototype drugs as examples. Prerequisites: Pharm. 501, 502.

590. **COLLOQUIUM (1-3)**

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

PHILOSOPHY (PHIL)

CARL R. HAUSMAN, *Head of the Department*
247 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Anderson, Hausman, Johnstone, Kockelmans, Lingis, Rosen, Seeborn, and Verene.

Graduate Faculty: Associate Members Flay, Ginsberg, Goldman, Price, Tsugawa, and Vaught.

A thorough grounding in the history of philosophy is desirable for all students. Specialization is possible in areas (such as aesthetics, metaphysics, ethics, social philosophy, logic, and history and philosophy of science); in movements of thought (such as rationalism, empiricism, idealism, phenomenology, and existentialism); or in any of the major figures in the history of western philosophy. Specialization is also possible in a joint program with the Department of Mathematics in logic and the foundations of mathematics, and with the Department of Physics in philosophy of science. Undergraduate preparation to the extent of a strong minor is advisable. The department may waive the requirement of a thesis for an M.A. candidate.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

PHILOSOPHY (PHIL)

406. **MEDIEVAL PHILOSOPHY (3)**

408. **STUDIES IN SOCIAL AND POLITICAL PHILOSOPHY (3)**

410. **STUDIES IN GREEK PHILOSOPHY (3-6)**

411. **STUDIES IN MODERN PHILOSOPHY (3-6)**

412. **STUDIES IN CONTEMPORARY PHILOSOPHY (3-6)**

413. **PHILOSOPHY OF LITERATURE (3)**

414. **AESTHETIC THEORY (3)**

417. **STUDIES IN NINETEENTH-CENTURY PHILOSOPHY (3-6)**

419. **PHILOSOPHICAL BACKGROUNDS OF AMERICAN THOUGHT (3)**

420. **PHILOSOPHY OF HISTORY (3)**

421. **STUDIES IN THE PHILOSOPHY OF SCIENCE (3)**

424. **STUDIES IN PHILOSOPHY OF RELIGION (3)**

426. **METAPHYSICS (3-6)**

427. **ADVANCED ETHICS (3)**

428. (Math. 428) LOGICAL THEORY (3)
429. SEMANTICS: PHILOSOPHY OF LANGUAGE AND SYMBOLISM (3)
432. (S.T.S. 432) MEDICAL ETHICS (3)
435. (S.T.S. 435) THE INTERRELATION OF SCIENCE, PHILOSOPHY, AND RELIGION (3)
494. (Ph.Ed. 494) MAN, WORLD, AND SPORT — A PHILOSOPHICAL INQUIRY (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. ETHICS: HISTORICAL AND SYSTEMATIC (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.
504. SOCIAL AND POLITICAL PHILOSOPHY (3-6) Critical study of basic problems in their historical and functional setting.
505. PHILOSOPHY OF WESTERN RELIGION (3-6) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.
506. SEMINAR IN ANCIENT PHILOSOPHY (3-6) Study of one or more important men or movements in ancient philosophy.
508. SEMINAR IN MODERN PHILOSOPHY (3-6) Men and movements in philosophy from the Renaissance through the nineteenth century.
509. SEMINAR IN CONTEMPORARY PHILOSOPHY (3-6) Men and movements in twentieth-century philosophy.
512. ADVANCED TOPICS IN PHILOSOPHY OF SCIENCE (3-6) Crucial problems in the theory of science and scientific method.
513. (Psy. 513) PRINCIPLES AND METHODS OF EMPIRICAL SCIENCE (3) Scientific methodologies and their presuppositions, with special emphasis on behavioral and social sciences.
514. SEMINAR IN NINETEENTH-CENTURY PHILOSOPHY (3-6) Study of a philosopher or philosophical movement of the nineteenth century.
515. PHILOSOPHICAL METHOD (3-6) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.
516. SEMINAR IN AESTHETICS (3-6) Problems and theories in the nature of art.
526. SEMINAR IN METAPHYSICS (3-6) Formulation and analysis of metaphysical problems in the various fields of philosophy.
530. PHILOSOPHY RESEARCH SEMINAR (1-12) Study of selected philosophical problems with an emphasis on techniques of philosophical research.
543. PROPOSITIONAL AND PREDICATE LOGIC (3) The theory and metatheory of propositional logic, with an introduction to predicate logic.
554. (Math. 554) LOGIC AND METAMATHEMATICS (3) Completeness, Lowenheim-Skolem and compactness theorems. First-order arithmetic, recursiveness, and the incompleteness and consistency of arithmetic. Prerequisite: Phil. 428.
590. COLLOQUIUM (1-3)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

PHYSICAL EDUCATION (PH ED)

KARL G. STOEDEFALKE, *Associate Dean for Academic Affairs*
274 Recreation Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Buskirk, Cavanagh, Christina, Gross, Harris, Hodgson, Hunt, Kamon, Landers, Lucas, Lundegren, Mendez, Morehouse, Nelson, Stoedefalke, and van der Smitten.

Graduate Faculty: Associate Members Alles, Anderson, Eck, Gallagher, Magnusson, Nicholas, Sabock, Scannell, Shute, Smith, St. Pierre, and Thompson.

The master's program is research-oriented and is designed to increase a student's professional competence as a teacher and future doctoral candidate, while the doctoral program is directed toward careers in research and in teaching at the advanced undergraduate and graduate levels in colleges and universities. The graduate programs are directed toward involvement of the student in gaining greater depth of understanding regarding the foundations of physical education. All degrees require experience with research to enable the student to better analyze problems, assess information, draw logical conclusions, and apply research findings.

Areas of specialization include (1) adapted physical education, (2) administration-supervision, (3) biomechanics (applied anatomy and kinesiology), (4) exercise specialist, (5) health education, (6) history of sport and physical education, (7) motor learning, (8) performance assessment, (9) physiology of exercise (physical conditioning, physical fitness, and performance stress), (10) psychosocial foundations of physical activity, and (11) recreation and parks.

Admission to the graduate program requires a bachelor's or master's degree in physical education or its equivalent in comparable course work and acceptable performance on the Graduate Record Examination. Especially desirable is a concentration in the physical, biological, behavioral, or social sciences depending upon the intended area of specialization. Admission to doctoral study requires demonstrated research ability in the form of a thesis or published research. A student who has earned a master's degree in recreation and parks and meets the above requirement may enter a doctoral program in physical education with specialization in recreation and parks. Students must demonstrate proficiency in use of the English language. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language—French, German, Russian, Spanish, or another language upon petition.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Recreation and Parks.

HEALTH EDUCATION (HL ED)

405. PREVENTION AND CARE OF ATHLETIC INJURIES (3)

408. INJURY CONTROL (3)

411. PRINCIPLES AND METHODS OF TEACHING SAFETY EDUCATION (3)

421. INTEGRATING HEALTH EDUCATION INTO THE SCHOOL PROGRAM, K-12 (3)

443. ALCOHOL EDUCATION (3)

450. HEALTH EDUCATION PRACTICUM (3-10)

456. ADVANCED TECHNIQUES IN SCHOOL COMMUNITY HEALTH EDUCATION (3)

457. CONSUMER HEALTH EDUCATION (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

511. (ANTHY. 511) HEALTH IMPLICATIONS IN THE GROWTH AND DEVELOPMENT OF SCHOOL CHILDREN (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: Hl.Ed. 215.

513. (Anthy. 513) **HEALTH IMPLICATIONS IN MATURITY AND AGING (3)** Changes in the human body in maturity and aging. Theories and mechanisms of physiologic aging with implications for health education. Prerequisite: HI.Ed. 511.

521. **PROBLEMS IN SCHOOL HEALTH ADMINISTRATION (3)** Critical concerns in the development and coordination of curriculum, policies, and evaluation of health education and services in school systems. Prerequisite: HI.Ed. 456.

530. (Ph.Ed. 530, Rc.Pk. 530) **RESEARCH TECHNIQUES IN HEALTH AND PHYSICAL EDUCATION AND RECREATION (3)** Research techniques, including methods, research design, techniques for data collection, as applied to relevant problems in the health education field.

552. **CURRENT HEALTH EDUCATION ISSUES (3)** Analysis of scientific and political foundations of current issues within health education tasks, with emphasis on research and action implications.

PHYSICAL EDUCATION (PH ED)

400. **ADAPTED PHYSICAL EDUCATION (3)**

402. **PHYSICAL EDUCATION FOR CHILDREN WITH LEARNING PROBLEMS (2)**

412. **CONTEMPORARY PROBLEMS OF TEACHING PHYSICAL EDUCATION IN THE INNER CITY SCHOOLS (3)**

420. **PSYCHOSOCIAL DIMENSIONS OF PHYSICAL ACTIVITY (3)**

442. **SPORT IN ANTIQUITY (3)**

450. **CURRENT RESEARCH LITERATURE IN PHYSICAL EDUCATION (3)**

452. **METHODS, MATERIALS, AND PRINCIPLES OF PHYSICAL EDUCATION IN THE ELEMENTARY SCHOOL (3)**

455. **STATISTICAL METHODS IN HEALTH, PHYSICAL EDUCATION, AND RECREATION (3)**

456. **PHYSICAL FITNESS APPRAISAL (3)**

457. **EXERCISE PRESCRIPTION (2)**

460. **METHODS AND PRINCIPLES OF ATHLETIC COACHING (3)**

462. **ADMINISTRATION OF ATHLETIC PROGRAMS (2)**

463. **ACQUISITION OF MOTOR SKILLS (3)**

470. **HISTORY AND THEORY OF DANCE IN EDUCATION (2)**

471. **EUROPEAN AND AMERICAN FOLK DANCE (2)**

480. **EXERCISE PHYSIOLOGY (3)**

483. **MOTOR PATTERNS OF CHILDREN (3)**

484. **KINESIOLOGY (3)**

489. **INTRAMURAL ATHLETICS (3)**

490. **INTRODUCTION TO TESTS AND MEASUREMENTS IN HEALTH AND PHYSICAL EDUCATION (3)**

491. **ORGANIZATION AND ADMINISTRATION OF HEALTH AND PHYSICAL EDUCATION IN SCHOOLS (3)**

494. (Phil. 494) **MAN, WORLD, AND SPORT — A PHILOSOPHICAL INQUIRY (3)**

495. **HISTORY OF SPORT IN AMERICAN SOCIETY (3)**

496. **INDEPENDENT STUDIES (1-12)**

497. **SPECIAL TOPICS (1-6)**

500. (Rc.Pk. 500) **INDIVIDUAL STUDY AND RESEARCH PROJECTS (1-10)** Prerequisite: Ph.Ed. 530.

520. **PSYCHOLOGY OF SPORT (3)** Study of man's psychological behavior in sport and physical activity; development of somatopsychic theory of physical activity. Prerequisite: 6 credits in psychology.

522. **SPORT IN SOCIETY (3)** Examination of the cultural phenomenon of sport; social behavior in sport; institution of sport and relationship with other social institutions. Prerequisite: 3 credits in sociology.

525. **SOCIAL PSYCHOLOGY OF SPORT (3)** Theory and research concerning the social-psychological basis for understanding social interaction and performance in team and individual sport settings. Prerequisite: 3 credits in social psychology at the 400 or 500 level.

530. (Hl.Ed. 530, Rc.Pk. 530) **RESEARCH TECHNIQUES IN HEALTH AND PHYSICAL EDUCATION AND RECREATION (3)** Research techniques, including methods, research design, techniques for data collection, as applied to relevant problems in the health education field.
532. **TESTS AND MEASUREMENTS IN PHYSICAL EDUCATION (3)** Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.
534. **STUDIES IN CURRICULUM CONSTRUCTION IN PHYSICAL EDUCATION (3)** Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction.
535. **MODERN FOREIGN SYSTEMS OF SPORT AND PHYSICAL EDUCATION (3)** Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.
550. **SEMINAR IN HEALTH AND PHYSICAL EDUCATION (1-6)** An in-depth analysis of current problems confronting the profession.
560. **ADMINISTRATIVE PROBLEMS OF PHYSICAL EDUCATION IN SCHOOLS (3)** Solutions to problems emerging from the administration of physical education in schools, fitting physical education in the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.
563. **MOTOR LEARNING (3)** Analysis of research evidence related to motor skills; characteristics of beginning and advanced performers; relevant learning principles.
565. **NEUROMUSCULAR PERFORMANCE (3)** Integrative action of the neural and muscular systems in effecting human movement with emphasis on motor performance. Prerequisites: Ph.Ed. 480, 490.
567. (Phsio. 567) **ADVANCED EXERCISE PHYSIOLOGY (3)** Physiological changes during exercise with emphasis on the effects of physical conditioning and training. Prerequisites: Biol. 472, Ph.Ed. 480.
568. (Phsio. 568) **ERGONOMICS (3)** Anthropometric, biomechanical, and physiological characteristics of working man and their importance in the man-machine-environment complex. Prerequisites: Biol. 472, Ph.Ed. 480; I.E. 408 recommended for engineering students.
575. **MOTOR PERFORMANCE OF THE HANDICAPPED (3)** Motor performance of physically handicapped and mentally retarded. Activities and therapeutic exercises for the formulation of individualized programs. Prerequisites: Cn.Ed. 409, E.E.C. 410.
576. **INTERNSHIP IN ADAPTED PHYSICAL EDUCATION (3)** Supervised internship in recreational, educational, or clinical situations; assessment of motor performances, evaluation of activities, and staff conference participation.
577. (Phsio. 577) **APPLIED CARDIOVASCULAR PHYSIOLOGY (2)** In-depth study of cardiovascular system physiology. Prerequisites: 4 credits in physiology at the 400 or 500 level.
580. (Phsio. 580) **ANALYSIS OF BODY COMPOSITION (2)** Study of the methods employed in the analysis of body composition. Prerequisite: Biol. 472 or 3 credits in physiology at the 400 or 500 level.
581. **BIOMECHANICS (3)** Kinetic and kinematic analyses of human motion utilizing electromyography and stroboscopic-photographic techniques. Prerequisite: Ph.Ed. 480.
582. **ADVANCED KINESIOLOGY (3)** Analysis of sports movements utilizing cinematography, electronic devices, and related research instruments.
583. **SPECIAL TOPICS IN BIOMECHANICS (1-6)** Critical review of current research in biomechanics, culminating in individual research projects. Prerequisite: Ph.Ed. 581 or 582.
584. **ELECTROMYOGRAPHIC KINESIOLOGY (3)** The theoretical background and practical application of electromyography in understanding human movement and the function of muscles. Prerequisites: Ph.Ed. 480, 484.
585. (Phsio. 585) **APPLIED PHYSIOLOGY: THERMAL (3)** Physiological mechanisms activated by exposure to environmental temperature. Prerequisite: Ph.Ed. 480 or 3 credits in physiology at the 400 or 500 level.

586. RESEARCH METHODS IN APPLIED PHYSIOLOGY (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.
587. (Phiso. 587) APPLIED PHYSIOLOGY: AMBIENT PRESSURE (3) Physiological mechanisms activated by exposure to environmental pressure. Prerequisite: Ph.Ed. 480 or 3 credits in physiology at the 400 or 500 level.
588. SPECIAL TOPICS IN APPLIED PHYSIOLOGY (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Ph.Ed. 585.
595. PHILOSOPHY OF SPORT AND PHYSICAL EDUCATION (3) Prerequisite: Ph.Ed. 491 or Rc.Pk. 465.

PHYSICS (PHYS)

ROLAND H. GOOD, JR., *Head of the Department*
104 Davey Laboratory

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Atwater, Barsch, Bleuler, Cutler, Eastman, Feuchtwang, Fleming, Frankl, Freed, Good, Graetzer, Grotch, Henisch, Herman, Kazes, Kendall, Lang, Madjid, McCammon, McCubbin, Pliva, Polo, Pratt, Reed, Shaw, Skudrzyk, Strother, Thwaites, Tsong, Vedam, Whitfield, and Wiggins.

Graduate Faculty: Associate Members Cole, Lannin, Lochstet, Maynard, and Sakurai.

Graduate instruction and research opportunities are available in atomic and molecular physics, nonlinear optics, field emission and field ion microscopy, many aspects of solid-state and surface physics, low-temperature physics, ionosphere and vacuum physics, acoustics, physics of biological compounds, nuclear physics, theoretical particle physics, quantum field theory, and general relativity. Work in some areas is conducted in cooperation with the Department of Biophysics, the Materials Research Laboratory, the Ionosphere Research Laboratory, and the Applied Research Laboratory. Study programs for applied options are arranged on an individual basis.

For the Ph.D. degree, knowledge of a foreign language may be required depending on the area of research. For the M.S. and M.Ed. degrees, the nonthesis option is available subject to approval by the department head. The M.Ed. program requires at least 18 credits in physics, which may include up to 6 credits for research, 6 additional nonresearch credits in science, and at least 6 credits in education.

A bachelor's degree in physics or an allied field is required for admission to the M.S., D.Ed., and Ph.D. programs. For admission to the M.Ed. program a student is required to have completed one year of general college physics plus two acceptable intermediate courses in physics, mathematics through integral calculus, and 18 credits in education and related psychology. Students with a 2.50 or higher junior-senior average in physics and mathematics will be considered for admission to the M.S., D.Ed., and Ph.D. programs. For admission to the M.Ed. program, the minimum requirement is a 2.50 junior-senior average in all courses. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Exceptions may also be made for applicants for doctoral programs who have completed master's degrees at other institutions.

PHYSICS (PHYS)

400. INTERMEDIATE ELECTRICITY AND MAGNETISM (4)
402. ELECTRONICS FOR SCIENTISTS (4)
406. NUCLEAR PHYSICS (3)
410. INTRODUCTION TO QUANTUM MECHANICS (3)
412. SOLID STATE PHYSICS I (3)

- 413. SOLID STATE PHYSICS II (3)
 - 419. (A.M. 419) THEORETICAL MECHANICS (3)
 - 420. THERMODYNAMICS (3)
 - 421. KINETIC THEORY AND STATISTICAL MECHANICS (3)
 - 433. MECHANICS AND FLUID PHYSICS FOR TEACHERS (3)
 - 443. INTERMEDIATE ACOUSTICS (3)
 - 454. ATOMIC AND NUCLEAR PHYSICS (3)
 - 456. ATOMIC AND MOLECULAR PHYSICS (3)
 - 457. EXPERIMENTAL PHYSICS (1-2 per term)
 - 458. INTERMEDIATE OPTICS (4)
 - 461. (A.M. 461) THEORETICAL MECHANICS (3)
 - 467. INTERMEDIATE ELECTRICITY AND MAGNETISM (3)
 - 471. QUANTUM THEORY OF ATOMS AND MOLECULES (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
510. GENERAL RELATIVITY (3) Foundations of general relativity; physics of metric spaces, tensor calculus; particle dynamics. Applications to stellar structure and cosmology. Prerequisites: Phys. 530; Phys. 525 or Math. 523.
511. APPLICATIONS OF GENERAL RELATIVITY (3) Einstein's equations; empty and matter-filled spaces; conservation laws; Schwarzschild, Nordström-Reissner and Kerr solutions; solar system tests; gravitational waves. Prerequisite: Phys. 510.
- 512-513. INTRODUCTION TO THE QUANTUM THEORY OF SOLIDS (3 each) Energy band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisites: Phys. 412, 517.
517. STATISTICAL MECHANICS (3) Classical and quantum statistics; statistical thermodynamics; the Boltzmann transport equation; methods illustrated with applications to physical problems. Prerequisites: Phys. 420, 561.
518. ADVANCED TOPICS IN THERMODYNAMICS AND STATISTICAL MECHANICS (3) Selected topics related to nonequilibrium thermodynamics, many-body problem, fluctuations, and statistical theory of random processes. Prerequisite: Phys. 517.
524. PHYSICS OF SEMICONDUCTORS (3) Band structures, theory of electron and hole conduction, transport properties, excess carrier distributions, p-n junctions, metal-semiconductor contacts, semiconductor surfaces. Prerequisite: Phys. 412.
525. METHODS OF THEORETICAL PHYSICS (3) Vector and tensor analysis; generalized coordinate systems; matrices and linear vector spaces of finite and infinite dimensionality; calculus of variations. Prerequisite: advanced calculus.
526. METHODS OF THEORETICAL PHYSICS (3) Continuation of Phys. 525: complex variables; Hilbert space; Green's functions; orthogonal functions and boundary value problems. Prerequisite: Phys. 525.
530. THEORETICAL MECHANICS (3) Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.
532. ADVANCED THEORETICAL MECHANICS (3) Least action principle, canonical transformations, Lagrange and Poisson brackets, Hamilton-Jacobi equations, classical theory of fields. Prerequisite: Phys. 530.
533. THEORETICAL ACOUSTICS (3) Vibrating systems; transmission of disturbances through elastic and viscoelastic media. Prerequisite: Phys. 530.
550. APPLIED GROUP THEORY (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510 or Phys. 525.

- 553-554. NUCLEAR PHYSICS (3 each) Theory of nuclear structure and nuclear reactions; intermediate-energy nuclear theory; pion physics. Prerequisite: Phys. 562.
557. ELECTRICITY AND MAGNETISM (3) Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric and magnetic properties of material media.
558. ADVANCED ELECTRICITY AND MAGNETISM (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.
559. GRADUATE LABORATORY (1) Introduction to techniques and instrumentation used in modern physics laboratories. Includes experience in planning experiments and working in research laboratories.
- 561-562. QUANTUM MECHANICS (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.
- 563-564. ADVANCED QUANTUM MECHANICS (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.
571. ATOMIC PHYSICS (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.
572. MOLECULAR PHYSICS (3) Electronic and nuclear motions in molecules, molecular spectra and structure. Prerequisite: Phys. 571.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6) (e.g., surface physics, tunneling theory, field-ion microscopy, liquid helium, superconductivity, vacuum physics, ion optics, nonlinear optics, many-body theory.)

PHYSIOLOGY (PHSIO)

ELSWORTH R. BUSKIRK, *Chairman of the Committee on Physiology*
119 Noll Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Amann, Anthony, Arnett, Bardin, Bullock, Buskirk, Cornwell, Eberhart, Gaffney, Harrison, Hodgson, Hollis, Jefferson, Kamon, LaNoue, Leach, Martin, McCarl, Mendez, Morgan, Mortimore, Mueller, Mumma, Nahrwold, Neely, Pegg, Ravizza, Rose, Scholz, Smyth, Wangness, Whitfield, Wickersham, and Zelis.

Graduate Faculty: Associate Members Green, Li, Mitchell, Neff, Nellis, Nicholas, Rannels, Ward, and Wenger.

This is an intercollege program designed to enable students to obtain an integrated series of courses encompassing both the fundamentals of physiology and advanced training in a specialized area. Courses can be taken at either The Milton S. Hershey Medical Center or at University Park.

Graduate instruction in physiology is under the direction of a program committee composed of graduate faculty representing several departments or groups at University Park actively participating in the physiology program — including the areas of animal industry, animal nutrition, biochemistry, bioengineering, biology, biophysics, physical education, psychology, veterinary science, and zoology — as well as the Department of Physiology at The Hershey Medical Center. The instructional staff is composed of faculty in those departments offering graduate courses in various areas of specialization in physiology. The program, including courses, laboratory experience, and original research, is designed for completion in three to four academic years. The communication and foreign language requirement for the Ph.D. degree may be satisfied by one of several options including intermediate knowledge of one foreign language.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

Deficiencies in chemistry, mathematics (through calculus), physics, or biological science must be made up early in the student's graduate program. All candidates (master's and doctoral) must complete a general basic laboratory course in physiology (combined cellular, mammalian, and comparative) before choosing an area of specialization. Possible areas of specialization are cardiovascular and respiratory physiology; cellular and subcellular physiology; comparative physiology; environmental physiology; exercise physiology; physiology of nutrition and metabolism; neurophysiology; and reproductive physiology. The graduate committee for majors shall be appropriately represented by members of the physiology program committee and those of the area of specialization who shall have the responsibility and jurisdiction for determining the course program and research acceptable in satisfying degree requirements. The nonthesis option is available for the M.S. degree.

The following courses, among others, are available for physiology majors, and their descriptions may be found under the offerings of several departments: Agro. 512, 545; A.I. 510, 514; A.Ntr. 401, 501; Anthy. 507; Bioch. 401, 402, 417, 437, 438, 501, 510, 511, 512, 519; Bio.E. 402; Biol. 409, 428, 437, 472, 473, 479, 538, 539, 550; Bphys. 430, 473, 587, 588; Cmp.Sc. 402, 410; D.Sc. 431; Ed.Psy. 400, 406, 506, 507; E.E. 569; Fd.Sc. 521; Hl.Ed. 511, 513; Meteo. 505; Micrb. 400, 401, 414, 508; Nuc.E. 415, 420; Nutr. 452, 457, 458, 459, 530, 552, 557; Ph.Ed. 456, 480, 565, 586, 588; Phys. 400, 402, 420; Psy. 402, 403, 455, 503; Stat. 451, 461, 462, 464; V.Sc. 405, 418, 525, 528, 535.

The following courses in anatomy and biochemistry are offered at The Milton S. Hershey Medical Center: Anat. 501, 502, 505, 510, 512, 513, 515, 530, 535, 542, 543, 545, 550, 590, 596, 597; B.Chem. 502, 503, 504, 513, 523, 551, 553, 590, 596, 597. Descriptions of these courses may be found under the designated program.

PHYSIOLOGY (PHSIO)

*520. MEDICAL PHYSIOLOGY (2) Cellular physiology including membrane permeability, bioelectric potentials, muscular contractions, secretion; metabolic physiology, including control of metabolism by hormones.

*521. MEDICAL PHYSIOLOGY (3) Organ physiology; examination of respiratory, renal, gastrointestinal and cardiovascular physiology.

*522. PHYSIOLOGY LABORATORY (1) Practical exercises in the areas of neuromuscular physiology, metabolism and endocrinology. Prerequisites: one year of biology, two years of chemistry, and one year of physics. Concurrent: Phsio. 520.

*523. PHYSIOLOGY LABORATORY (1) Practical exercises in the areas of cardiovascular, respiratory, renal and gastrointestinal physiology. Prerequisite: Phsio. 520. Concurrent: Phsio. 521.

*525. GENERAL PHYSIOLOGY (2) Cellular processes of accumulation membrane transport, bioelectric potentials, contraction, and secretion in erythrocytes, nerves, sensory receptors, muscles, glands, excretory organs.

*530. METABOLIC AND ENDOCRINE PHYSIOLOGY (3) Regulation of carbohydrates, fatty acid and protein metabolism; regulation of hormone secretion; effects of hormones on water and cell metabolism.

*532. REPRODUCTIVE PHYSIOLOGY (3) Physiology of mammalian reproductive systems, including synthesis, secretion and mechanism of action of the steroids and polypeptide hormones involved. Prerequisites: Phsio. 520, 521.

*534. HEART AND SKELETAL MUSCLE (2) Discussion of structure, chemistry, and physiology of heart and skeletal muscle. Prerequisites: Phsio. 520, 521.

*536. GASTROINTESTINAL PHYSIOLOGY (2) Mechanisms of absorption and secretion by stomach,

*This course is offered at The Milton S. Hershey Medical Center.

intestine, pancreas, and gallbladder. Neural and hormonal regulation, bioelectric potentials, pathophysiology. Prerequisite: Phsio. 521.

567. (Ph.Ed. 567) **ADVANCED EXERCISE PHYSIOLOGY (3)** Physiological changes during exercise, with emphasis on the effects of physical conditioning and training. Prerequisites: Biol. 472, Ph.Ed. 480.

568. (Ph.Ed. 568) **ERGONOMICS (3)** Anthropometric, biomechanical, and physiological characteristics of working man and their importance in the man-machine-environment complex. Prerequisites: Biol. 472, Ph.Ed. 480; I.E. 408 recommended for engineering students.

571. (Biol. 571) **ANIMAL PHYSIOLOGY (2)** Mammalian cardiovascular system; mammalian neurophysiology; excitable tissue, sensory systems, motor systems, and autonomic system. Prerequisite: Biol. 472.

572. (Biol. 572) **ANIMAL PHYSIOLOGY (2)** Mechanisms involved in the activity and control of gastrointestinal function, respiration, and renal regulation of blood and body fluids. Prerequisite: Biol. 472.

573. (Biol. 573) **ANIMAL PHYSIOLOGY (2)** Hypothalamic-hypophyseal relationships. Reproductive cycle regulation, endocrine control of fluid balance, body temperature, energy homeostasis and metabolism of protein and minerals. Prerequisite: Biol. 472.

577. (Ph.Ed. 577) **APPLIED CARDIOVASCULAR PHYSIOLOGY (2)** In-depth study of cardiovascular system physiology. Prerequisite: 4 credits in physiology at the 400 or 500 level.

580. (Ph.Ed. 580) **ANALYSIS OF BODY COMPOSITION (2)** Study of the methods employed in the analysis of body composition. Prerequisite: Biol. 472 or 3 credits in physiology at the 400 or 500 level.

585. (Ph.Ed. 585) **APPLIED PHYSIOLOGY: THERMAL (3)** Physiological mechanisms activated by exposure to environmental temperature. Prerequisite: Ph.Ed. 480 or 3 credits in physiology at the 400 or 500 level.

587. (Ph.Ed. 587) **APPLIED PHYSIOLOGY: AMBIENT PRESSURE (3)** Physiological mechanisms activated by exposure to environmental pressure. Prerequisite: Ph.Ed. 480 or 3 credits in physiology at the 400 or 500 level.

589. **PHYSIOLOGY OF PULMONARY RESPIRATION (2)** Physiology of the lung, including physical and chemical properties, synthesis of cellular constituents, gas exchange, and effects of unusual environments. Prerequisite: 3 credits of physiology at 400 or 500 level.

†590. **COLLOQUIUM (1-3)**

†596. **INDIVIDUAL STUDIES (1-6)**

†597. **SPECIAL TOPICS (1-6)**

PLANT PATHOLOGY (PPATH)

SAMUEL H. SMITH, *Head of the Department*
211 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Ayers, Bloom, Boyle, Cole, Kingsolver, Kneebone, Leath, Lukezic, MacKenzie, Merrill, P. Nelson, R. Nelson, Oswald, Schein, Schisler, Sherwood, Smith, Toussoun, and Wuest.

Graduate Faculty: Associate Members Davis, Hickey, Pell, Pennypacker, and Stouffer.

†This course is offered at The Milton S. Hershey Medical Center and at University Park.

Plant pathology is the study of disease in plants and concerns the dynamic interaction between the plant, the causal agent (bacteria, fungi, viruses, nematodes, etc.), and their environments. A student prepares for a professional career in research, teaching, extension, or industry through advanced studies of the principles of plant infection, the physiology of disease in plants, the ecology of root diseases, the nature and inheritance of disease resistance in plants, epidemiology, ecology and physiology of air pollution injury to plants, or plant disease control by biological or chemical means. A student also may specialize in the nature and control of the diseases of forest trees, agronomic or horticultural crops, and commercial mushrooms. Advanced studies in applied mycology, related to the production of the commercial mushroom, also may be taken. Modern, well-equipped laboratories, controlled environment facilities and greenhouses, and well-developed field research areas are available for graduate study.

The Master of Agriculture degree is offered to provide professional training in plant pathology with more of a crop orientation than is available under the M.S. program. In addition to the courses required for an M.S. degree, further study in the areas of entomology and crop sciences is required. A thesis substitute, such as an internship report, or an adaptive or demonstrative activity whereby known technology or procedures are applied, is acceptable.

Competency in foreign language is not required for the Ph.D. degree; however, depending upon the nature of the thesis research and with the advice and consent of the doctoral advisory committee, competency in a foreign language may be judged to be an essential part of the doctoral studies of certain students.

For admission a student must present 42 credits in the natural sciences, including a minimum of 15 credits in the plant sciences and a minimum of 15 credits in mathematics, chemistry, or physics. Students with a strong background in agronomy, biochemistry, biophysics, botany, forestry, genetics, horticulture, or microbiology are usually well prepared for advanced study in plant pathology.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces and advisers that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

PLANT PATHOLOGY (PPATH)

401. THEORY AND CONCEPTS OF PLANT PATHOLOGY (3) *Mr. Merrill*
 402. DISEASES OF ECONOMIC PLANTS (2) *Mr. Merrill*
 403. INTRODUCTION TO EPIDEMIOLOGY (3) *Mr. Schein*
 408. PLANT PATHOLOGICAL TECHNIQUES (3) *Mr. Wuest*
 420. PLANT PATHOGENIC BACTERIA (3) *Mr. Lukezic*
 422. INTRODUCTION TO PLANT VIROLOGY (3) *Mr. Romaine*
 424. ENVIRONMENTAL PATHOLOGY (3) *Mr. Davis*
 429. PHYTONEMATOTOLOGY (3) *Mr. Bloom*
 430. HISTORY OF PLANT PATHOLOGY (2) *Mr. Merrill*
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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501. CLINICAL PLANT PATHOLOGY (1-3) Diagnosis and prognosis of disease; observe and evaluate the implementation of control practices. Prerequisite: P.Path. 408. *Mr. Cole*
 540. PLANT DISEASE CONTROL (3) Principles of plant disease control, including theoretical considerations involved in control by chemical and nonchemical means. *Mr. Cole*
 541. PHYSIOLOGY OF PLANT DISEASE (3) Physiology of the diseased plant, including the host response to the pathogen and parasitic properties of the pathogen. Prerequisite: Biol. 443. *Mr. Lukezic*
 542. EPIDEMIOLOGY OF PLANT DISEASES (4) Disease development in populations of plants, with emphasis on the impact of environment and control practices on rate of development. Prerequisite: 9 credits in plant pathology. *Mr. Pennypacker*
 543. PATHOGEN VARIATION AND HOST RESISTANCE (3) Mechanisms and implications of genetic variation in plant pathogens related to breeding for disease resistance in plants by genetic means. Prerequisite: P.Path. 401, Agro. 411, or Hort. 407. *Mr. Ayers*

544. **PATHOLOGICAL PLANT ANATOMY (2)** Structural manifestations occurring in diseased plants. Prerequisites: Biol. 407, P.Path. 408. *Mr. P. E. Nelson*
560. **PRINCIPLES OF PLANT PATHOLOGY (3)** Open-ended discussions of concepts of plant pathology, with emphasis on their interrelationships and their significance to the science. *Mr. R. R. Nelson*
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

POLITICAL SCIENCE (PL SC)

ROBERT S. FRIEDMAN, *Head of the Department*
112 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Albinski, Aspaturian, Brown, Chang, Eisenstein, Friedman, Gilberg, Keynes, and Kochanek.

Graduate Faculty: Associate Members Butterworth, Cimbala, King, Myers, O'Connor, and Spence.

Candidates for the M.A. will be comprehensively examined in one of the following fields: American politics, comparative politics, international relations, political philosophy, or public administration. Candidates following the thesis plan will also take course work in one other of these substantive fields. Candidates following the nonthesis plan will take course work in two of the above five fields. Ph.D. candidates will be comprehensively examined in three of the above fields, or in two departmental fields, and in a minor field or fields. Course work in scope of the discipline and methodology is required. The communication and foreign language requirement for the Ph.D. may be satisfied by competence in approved skills selected from among foreign languages, statistics or mathematics, and computer science.

Students with a 3.00 junior-senior average and appropriate course backgrounds, including at least the equivalent of 12 credits in political science, will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. At the master's level two letters of recommendation and scores on the Graduate Record Examination (verbal and quantitative ability) are required. Admission to the Ph.D. program will entail evaluation of two letters of recommendation, scores on the Graduate Record Examination (verbal and quantitative ability), and previous scholastic performance.

POLITICAL SCIENCE (PL SC)

401. **POLITICAL BEHAVIOR (3)** *Mr. King*
403. **THE LEGISLATIVE PROCESS (3)** *Mr. Keynes*
409. **QUANTITATIVE POLITICAL ANALYSIS (3)** *Messrs. King and Williams*
411. **AMERICAN POLITICAL THEORY (3)** *Mr. Spence*
412. **INTERNATIONAL ORGANIZATION: ECONOMIC AND SOCIAL FUNCTIONS (3)**
413. **GOVERNMENT AND POLITICS OF THE SOVIET UNION (3)** *Messrs. Aspaturian and Gilberg*
414. **FOREIGN POLICY OF THE SOVIET UNION (3)** *Mr. Aspaturian*
415. **INTERNATIONAL ORGANIZATION: POLITICAL AND SECURITY FUNCTIONS (3-6)** *Messrs. Aspaturian, Brown, and Butterworth*
416. **INTERNATIONAL LAW (3)** *Mr. Butterworth*

417. AMERICAN LOCAL GOVERNMENT AND ADMINISTRATION (3) *Messrs. O'Connor, Friedman, and Williams*
418. INTERNATIONAL RELATIONS THEORY (3) *Mr. Butterworth*
419. BUREAUCRACY AND PUBLIC POLICY (3) *Messrs. Friedman and Williams*
422. COMPARATIVE URBAN POLITICS (3) *Messrs. Gilberg and Myers*
425. GOVERNMENT AND POLITICS OF THE AMERICAN STATES (3) *Messrs. Friedman and O'Connor*
426. POLITICAL PARTIES (3) *Mr. King*
427. POLITICAL OPINION (3) *Mr. O'Connor*
431. ANCIENT AND MEDIEVAL POLITICAL THEORIES (3) *Mr. Spence*
433. (L.S. 433) THE LAW OF LABOR-MANAGEMENT RELATIONS (3)
438. NATIONAL SECURITY POLICIES (3) *Messrs. Brown and Myers*
441. THE AMERICAN LEGAL PROCESS (3) *Messrs. Eisenstein and Keynes*
442. AMERICAN FOREIGN POLICY (3) *Messrs. Brown and Butterworth*
443. CURRENT PROBLEMS IN AMERICAN FOREIGN POLICY (3) *Mr. Brown*
444. GOVERNMENT AND THE ECONOMY (3)
447. CONSTITUTIONAL LAW: THE FEDERAL SYSTEM (3) *Mr. Keynes*
448. CONSTITUTIONAL LAW: FIRST AMENDMENT FREEDOMS (3)
450. CANADIAN AND AUSTRALIAN POLITICS AND FOREIGN POLICIES (3) *Mr. Albinski*
451. COMPARATIVE POLITICAL ANALYSIS (3) *Mr. Albinski*
452. GOVERNMENTS AND POLITICS OF EASTERN EUROPE (3) *Mr. Gilberg*
453. POLITICAL PROCESSES IN UNDERDEVELOPED SYSTEMS (3-6) *Messrs. Chang, Kochanek, and Myers*
454. GOVERNMENT AND POLITICS OF AFRICA (3) *Mr. Brown*
455. GOVERNMENTS AND POLITICS OF WESTERN EUROPE (3) *Mr. Gilberg*
456. POLITICS AND INSTITUTIONS OF LATIN-AMERICAN NATIONS (3) *Mr. Myers*
457. INTERNATIONAL POLITICS OF LATIN AMERICA (3-6) *Mr. Myers*
458. GOVERNMENT AND POLITICS OF EAST ASIA (3-6) *Mr. Chang*
459. GOVERNMENT, POLITICS, AND INTERNATIONAL RELATIONS OF SOUTH ASIA (3) *Mr. Kochanek*
460. LIBERAL AND DEMOCRATIC POLITICAL THEORY (3) *Mr. Spence*
461. AUTHORITARIAN AND ELITIST POLITICAL THEORY (3) *Mr. Spence*
462. MARXIST AND SOCIALIST POLITICAL THEORY (3) *Mr. Spence*
466. COMPARATIVE FOREIGN POLICIES OF WESTERN EUROPE (3) *Mr. Brown*
468. INTERNATIONAL RELATIONS OF EAST ASIA (3) *Mr. Chang*
469. INTERNATIONAL RELATIONS OF SOUTH ASIA (3-6) *Mr. Kochanek*
473. CONSTITUTIONAL LAW: CIVIL RIGHTS (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
499. FOREIGN STUDY IN GOVERNMENT (2-6)
500. POLITICAL POWER (3-6) Subject to be announced.
505. EXECUTIVE POWER (3-6)
509. SCOPE AND METHOD OF POLITICAL SCIENCE (3-6) *Mr. King*
512. COMPARATIVE POLITICAL SYSTEMS (3-9) *Messrs. Albinski, Chang, Kochanek, and Myers*
513. SEMINAR IN COMPARATIVE POLITICAL PARTIES (3-6) Nature, function, organization, and leadership of parties; party systems, political culture, voting, and the institutional framework. *Messrs. Albinski and King*
515. INTERNATIONAL POLITICS (3-6)
516. SEMINAR IN INTERNATIONAL RELATIONS THEORY AND METHODOLOGY (3) A detailed analysis of major traditional and contemporary theory-building efforts and contemporary research techniques and orientations in international relations. *Mr. Butterworth*
517. INTERNATIONAL ORGANIZATION (3-6) *Mr. Aspaturian*
521. MODERN DEMOCRATIC POLITICAL THEORY (3-6) *Mr. Spence*

522. COMPARATIVE FOREIGN POLICIES (3-6) Major policies of selected nations which bear upon the search for international peace and security. *Mr. Aspaturian*
523. SOVIET POLITICAL BEHAVIOR (3) Forces which shape rivalries for power; decision-making processes; areas of agreement and dissent. *Messrs. Aspaturian and Gilberg*
524. FOREIGN POLICIES OF THE SOVIET BLOC (3-6) Major policies, the decision-making process, and the impact upon component members and external rivals for power. *Messrs. Aspaturian and Gilberg*
525. COMPARATIVE AMERICAN STATE AND LOCAL POLITICS (3-6) Literature and research in comparative state and local political systems in the United States. *Messrs. Friedman and O'Connor*
527. POLITICS AND LEGISLATIVE BEHAVIOR (3-6) Social factors which shape and determine the attitudes and decisions of American legislators and legislative bodies. *Messrs. Keynes and King*
529. FEDERAL SYSTEMS (3-6) Features of the American federal system compared with those of other nations using the federal form.
530. PUBLIC LAW (3-6) The nature of law and its role in modern society. *Mr. Eisenstein*
531. MARXISM AND POLITICAL SOCIALIST THEORIES (3) A systematic analysis and appraisal of major premises and deductions. *Mr. Aspaturian*
532. EMPIRICAL POLITICAL THEORY (3-6) The impact of scientific method upon traditional political thought. *Messrs. Keynes and Spence*
546. JUDICIAL PROCESS (3) Court functions in the political process; sources and limits of judicial power; perceptions of the judicial role; judicial decision making. Prerequisite: 12 credits in political science. *Messrs. Eisenstein and Keynes*
554. AFRICAN POLITICAL SYSTEMS (3-6) Impact of European colonialism; cultural and anthropological factors in political development; modernization and analysis of selected problems in contemporary Africa. Prerequisite: 3 credits of comparative government or international relations at the 400 level. *Mr. Brown*
572. (Pub.A. 572) INTERNATIONAL DEVELOPMENT ADMINISTRATION (3-6) The execution of foreign policies through national and international public and private organizations. *Messrs. Brown and LaPorte*
573. (Pub.A. 573) COMPARATIVE PUBLIC ADMINISTRATION (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Messrs. LaPorte and Myers*
574. (Pub.A. 574) SEMINAR IN THE ADMINISTRATION OF UNITED STATES FOREIGN AFFAIRS (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *Messrs. Brown and LaPorte*
586. THEORY OF BUREAUCRATIC AND ADMINISTRATIVE POLITICS (3-6) The role of the executive in government and politics; theories of administrative organization, organization behavior, and decision-making processes. *Mr. Friedman*
594. READINGS IN POLITICAL SCIENCE (1-6) Directed readings in selected areas of the discipline.
595. RESEARCH IN POLITICAL SCIENCE (1-6) Directed research in selected areas of the discipline.
597. SPECIAL TOPICS (1-6)

POULTRY SCIENCE (PTYSC)

KENNETH GOODWIN, *Head of the Department*
214 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Buss, Goodwin, Graves, Leach, MacNeil, and Mueller.

Graduate Faculty: Associate Member Mast.

The department offers two types of degree programs leading to the M.S. and/or Ph.D.: (1) a degree may be pursued in Poultry Science, with one of the following major fields of interest: animal nutrition, behavior, food science, genetics, management, and physiology, or (2) a degree may be pursued in one of the following disciplinary interdepartmental programs: animal nutrition, ecology, genetics, and physiology. In either case, direction of the student's program will be by a faculty member in the Department of Poultry Science. For the Ph.D., reading ability in one foreign language is required.

Students with professional interests other than research may earn the M.S. in Poultry Science without doing a thesis; in this option, a paper on a selected professional problem is required for graduation.

Admission requirements include 30 credits in the biological and physical sciences (chemistry, mathematics, and physics). Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

POULTRY SCIENCE (PTYSC)

405. POULTRY PRODUCTION TECHNOLOGY (3)

462. (Biol. 462) ANIMAL BEHAVIOR — ETHOLOGY (3)

463. (Biol. 463, Psy. 463) ANIMAL BEHAVIOR LABORATORY (1-2)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

502. POULTRY NUTRITION (2-4) *Mr. Leach*

503. POULTRY FARM MANAGEMENT (3) An analysis of poultry farm management problems and the application of research methods to a specific problem.

504. POULTRY MEAT AND EGG TECHNOLOGY (3) Analysis of current industry programs, effects of specific procedures on product quality, development of research programs. Offered even years. *Mr. MacNeil*

582. (Biol. 582, Psy. 582) RESEARCH IN ANIMAL BEHAVIOR (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Graves and Hale*

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

NOTE: See *Animal Science* under "Other Graduate Courses."

PSYCHOLOGY (PSY)

ROBERT M. STERN, *Acting Head of the Department*
417 Moore Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Cornwell, Craighead, Draguns, Gorlow, Guthrie, Hall, Kazdin, Landy, Leibowitz, Lundy, Mahoney, Martin, Mitzel, Noble, Palermo, Piers, Ravizza, Ray, Seibel, Sherif, Shotland, Stern, Taylor, Thevaos, Thomas, Urban, Warren, and Weimer.

Graduate Faculty: Associate Members Dubin, Farr, Kerr, Newcombe, and Whaley.

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, cognition, human information processing, perception, psycholinguistics, verbal learning and memory, physiological and comparative, clinical, developmental and child, engineering and human factors, industrial-organizational, social.

The communication and foreign language requirement for the Ph.D. degree does not specify a foreign language, but a student must demonstrate proficiency in English.

Requirements for admission include a broad undergraduate preparation, a minimum of 9 credits in psychology, and a satisfactory graduate student rating on the Miller Analogies Test and the Graduate Record Examination (general and advanced). Students with a 3.40 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.40 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants with master's degrees will have their admission evaluated with emphasis on the quality of their graduate programs.

PSYCHOLOGY (PSY)

402. SENSATION AND PERCEPTION (3)
403. INTRODUCTORY PHYSIOLOGICAL PSYCHOLOGY (3)
404. CONDITIONING AND LEARNING (3)
405. THE EXPERIMENTAL PSYCHOLOGY OF VISUAL PERCEPTION (3)
408. COMPARATIVE PSYCHOLOGY (3)
409. TECHNIQUES IN LABORATORY EXPERIMENTATION (2-6)
410. HISTORICAL ANTECEDENTS OF PSYCHOLOGY (3)
411. SYSTEMS OF PSYCHOLOGY AND THE RECENT PAST (3)
412. ABNORMAL PSYCHOLOGY (3)
413. BIOGRAPHICAL PSYCHOLOGY (3)
414. HUMANISTIC PSYCHOLOGY (3)
415. INTERMEDIATE EXPERIMENTAL DESIGN (3)
417. SOCIAL PSYCHOLOGY (3)
418. MEASUREMENT OF PERSONALITY (3)
419. MEASUREMENT AND SCALING (3)
420. (Ling. 420) ADVANCED PSYCHOLINGUISTICS (3)
421. ADVANCED COGNITIVE PSYCHOLOGY (3)
425. CHILD PSYCHOLOGY (3)
426. ADOLESCENCE (2-3)
430. MEMORY AND VERBAL LEARNING (3)
431. INDUSTRIAL PSYCHOLOGY (3)
432. INTRODUCTORY ENGINEERING PSYCHOLOGY (3)
433. PSYCHOLOGY OF OCCUPATIONAL BEHAVIOR (2)
434. INFORMATION-PROCESSING LABORATORY (1-6)
435. (M.E.R. 435) ENVIRONMENTAL STIMULATION AND BEHAVIOR (3)
436. MENTAL HEALTH IN SCHOOLS (3)
437. PSYCHOLOGY OF ADJUSTMENT (3)

438. THEORY OF PERSONALITY (3)
 441. INDUSTRIAL MOTIVATION AND MORALE (3)
 445. (I.F.S. 445) DEVELOPMENT THROUGHOUT ADULTHOOD (3)
 450. (Ed.Psy. 450) PRINCIPLES OF MEASUREMENT (3)
 455. PHYSIOLOGICAL PSYCHOLOGY LABORATORY (3)
 456. LABORATORY IN PSYCHOPHYSIOLOGY (2-4)
 457. EXPERIMENTAL SOCIAL PSYCHOLOGY (4)
 463. (Biol. 463, Pty.Sc. 463) ANIMAL BEHAVIOR LABORATORY (1-2)
 470. (I.F.S. 470) SOCIAL LEARNING FOUNDATIONS OF BEHAVIOR CHANGE (3)
 471. PSYCHOLOGY AND WOMEN (3)
 474. PSYCHOLOGY OF EXCEPTIONAL CHILDREN (3)
 482. INTRODUCTION TO CLINICAL PSYCHOLOGY (3)
 483. THE PSYCHOLOGY OF FEAR AND STRESS (3)
 484. CLINICAL NEUROPSYCHOLOGY (3)
 496. INDEPENDENT STUDIES (1-12)
503. PHYSIOLOGICAL PSYCHOLOGY (2-6) Correlations between structure and function of nervous system and human consciousness; laws and theories in fields of sensation, attention, association, affection, and thought. Prerequisite: 9 credits in psychology.
505. RESEARCH PROBLEMS IN PSYCHOLOGY (1-15) Prerequisite: 12 credits in psychology.
510. HISTORY OF THE HIGHER MENTAL PROCESSES (3) Stress upon theoretical, conceptual, and methodological problems involved in studying human thinking, language, memory, cognition, and other skills. Prerequisite: Psy. 410 or 411.
511. SEMINAR IN CONTEMPORARY PSYCHOLOGY (1-9) Critical review of readings on a topic of current interest, either in content or methodology, within psychology. Prerequisite: 9 credits in psychology.
513. (Phil. 513) PRINCIPLES AND METHODS OF EMPIRICAL SCIENCE (3) Scientific methodologies and their presuppositions, with special emphasis on behavioral and social sciences.
515. ADVANCED STATISTICS IN PSYCHOLOGY AND EDUCATION (3) Correlation theory and methods, discriminant analysis, and factor analysis; applications to mental test theory. Prerequisite: Psy. 415 or Ed.Psy. 506.
516. SEMINAR IN QUANTITATIVE MODELS (3-9)
517. ADVANCED SOCIAL PSYCHOLOGY (3) Problems of theory and of research methods with emphasis on persisting issues relevant to contemporary developments in social psychology. Prerequisites: Psy. 417; Psy. 15 or Stat. 200.
518. PROJECTS IN EXPERIMENTAL PSYCHOLOGY (2-4) Individual experimental projects; seminars on experimental design and instrumentation.
520. (Ling. 520) SEMINAR IN PSYCHOLINGUISTICS (3) Consideration of theoretical and research issues relevant to psychological aspects of language sounds, syntax and semantics, and other cognitive support.
522. PERSONNEL SELECTION AND APPRAISAL (3) Evaluation of models for personnel selection, placement, and performance appraisal in business and industry. Prerequisites: Psy. 431, Psy. 450 (Ed.Psy. 450).
523. SOCIAL-ORGANIZATION PSYCHOLOGY IN INDUSTRY (3) Analysis of the role of social and organizational variables as they affect employee performance and employee attitudes. Prerequisite: Psy. 431.
527. STATISTICAL INFERENCE AND EXPERIMENTAL DESIGN (3) Probability theory, sampling distributions, analysis of variance and covariance, analysis of trend, nonparametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 506.
529. (I.F.S. 529) SEMINAR IN CHILD DEVELOPMENT (1-6) Readings and reports on recent findings

in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

531. SEMINAR IN PERFORMANCE THEORY (3-9) Topics in theory and research on human performance in perceptual-motor and information-processing tasks. Prerequisite: Psy. 432.

533. ADVANCED ENGINEERING PSYCHOLOGY (3) Analysis of the role of the human operator in man-machine systems. Prerequisite: Psy. 432.

534. PRACTICUM IN INDUSTRIAL/ORGANIZATIONAL PSYCHOLOGY (1-3) Supervised application of psychological principles in industrial and governmental settings. Prerequisite: Psy. 431.

535. DEVELOPMENTAL PSYCHOLOGY (2-3) Developmental principles and concepts applied to psychological processes, with special reference to the experimental literature. Prerequisite: 9 credits in psychology.

536. (I.F.S. 536) RESEARCH METHODS IN DEVELOPMENTAL PROCESSES (3) Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology, and a course in statistics.

538. PSYCHOLOGY OF PERSONNEL DEVELOPMENT (3) Industrial training in relation to psychological learning-theory and experimental findings. Prerequisite: Psy. 431 or Ed.Psy. 421.

539. SEMINAR IN MOTIVATION AND EMOTION (3-9) Systematic status of instinct, drive, motive, will, purpose; methodology and results of physiological, experimental, and clinical investigation of basic drives.

540. SEMINAR IN CLINICAL PROBLEMS (1-9) Contemporary psychological theory, research, and methodology in relation to clinical psychology. Prerequisites: Psy. 542, 560.

541. PERSONALITY THEORY (3-4) Contemporary theories of personality; relevant research. Prerequisite: Psy. 438.

542. PSYCHOPATHOLOGY (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisite: Psy. 412.

543. RESEARCH DESIGN IN CLINICAL PSYCHOLOGY (3) Experimental and quasi-experimental designs, methodological problems, and techniques of experimental control in clinical psychology research. Prerequisite: 3 credits of statistics.

545. SEMINAR IN VERBAL LEARNING AND VERBAL BEHAVIOR (1-9)

549. (I.F.S. 549) DEVELOPMENTAL THEORY (3) Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.

555. THEORY AND PRACTICUM IN CLINICAL ASSESSMENT (3-9) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of testing procedures and clinical interviewing. Prerequisites: Psy. 541 or 542, and a course in measurement.

558. CLINICAL CHILD PSYCHOLOGY (3-9) Psychopathology of childhood; theories of etiology; diagnosis and treatment. Prerequisites: Psy. 555, 561.

559. (S.Psy. 559) THE INDIVIDUAL PSYCHOLOGICAL EXAMINATION (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

560. PRACTICUM IN CLINICAL METHODS (1-6) Supervised practice in the Psychology Clinic, including assessment, therapy, report writing, and staff participation. Prerequisite: Psy. 555.

561. CLINICAL PRACTICUM WITH CHILDREN (1-6) Diagnosis and counseling of child-parent problems of learning and adjustment. Prerequisites: Psy. 425, 426, 555.

563. BEHAVIOR MODIFICATION I (3) Conceptual foundations of principles, assessment methods, and research strategies.

564. BEHAVIOR MODIFICATION II (3) Survey and empirical evaluation of treatment strategies. Prerequisite: Psy. 563.

565. SEMINAR IN COMMUNITY PSYCHOLOGY (3) Application of social psychological research methods and principles to prevention and alleviation of behavior disorders in family and community settings.
566. CULTURAL PSYCHOLOGY (3) Experimental and descriptive research on culture and behavior in both Western and non-Western settings. Prerequisites: Psy. 417, 438, and 6 credits of statistics.
569. ADVANCED THEORY AND PRACTICUM IN COUNSELING AND PSYCHOTHERAPY (3-9) Theoretical issues, research, and practicum experience in psychotherapy.
571. SEMINAR IN SOCIAL PSYCHOLOGY (3-9) Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research.
580. THEORY AND CONSTRUCTION OF ATTITUDE SCALES (3) Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.
582. (Biol. 582, Pty.Sc. 582) RESEARCH IN ANIMAL BEHAVIOR (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.
583. DESIGNING RESEARCH IN SOCIAL PSYCHOLOGY (3) Comparative analysis of major methodological approaches including laboratory experiments, field experiments, quasi-experiments, and surveys. Prerequisites: Psy. 417; 3 credits in statistics.
584. ATTITUDE FORMATION AND CHANGE (3) Theory and method in research on attitude formation and change with emphasis on critical analysis and research problems. Prerequisites: Psy. 417; 3 credits in statistics.
585. INTERACTION PROCESSES WITHIN AND BETWEEN GROUPS (3) Small group processes as context for behavior and for self system. Emphasis on theory and research in laboratory and field. Prerequisites: Psy. 417; 3 credits in statistics.
586. THE SOCIAL PSYCHOLOGY OF COLLECTIVE ACTION (3) Social movements, crowds, audiences, and large groups explored for their impact upon the behavior of the individual member. Prerequisite: Psy. 417.
589. PROBLEMS IN CLINICAL RESEARCH (1-6) Prerequisite: Psy. 415.
590. COLLOQUIUM (1-3)
591. SEMINAR ON TEACHING PSYCHOLOGY (1-3) Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

PSYCHOSOCIAL SCIENCE (PS SC)

KATHRYN TOWNS, *In Charge of the Graduate Program in Psychosocial Science*
The Capitol Campus, Middletown, PA 17057

Degree Conferred: M.Ps.Sc.

Graduate Faculty: Senior Members Hudson, Lear, Nichols, and Whittaker.

Graduate Faculty: Associate Members Barton, Colman, Dexter, Knestrick, Shuttlesworth, Taylor, and Towns.

The program emphasizes practicum experience to equip students with necessary skills to cope effectively with the problems facing communities. Graduates of the program should be able to recognize problems, to outline and implement possible solutions to these problems, and to evaluate the

effectiveness of the solutions. To perform these functions the student must be aware of contemporary community needs, the impact of the community structure upon its individual members, and the techniques best suited to initiate productive change. Problems in drug abuse, delinquency, unemployment, housing, and other areas affecting the individual may be approached from a community agency base or from less formal community groups dealing with the problems.

The student is required to take 33 credits, 21 at the 500 level. The required practicum experience is field work under the supervision of a faculty member. A paper is required and will be defended orally before a committee of two faculty members and a staff member from the practicum site.

For admission, a student must have received a baccalaureate degree from an accredited institution with residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. Most applicants have degrees in psychology or sociology; however, experience in community agencies is weighed for applicants from other disciplines. Ordinarily, applicants are expected to be familiar with elementary statistics and may be requested to make up any deficiency without graduate credit. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Required courses include: So.Sc. 510, 520; Ps.Sc. 511, 521, 530. Elective courses for a public agency emphasis are: Ps.Sc. 500, So.Sc. 541, 542, 543. Elective courses for an emphasis in community organizing are: Ps.Sc. 500, So.Sc. 531, 532, 533. The majority of these courses are offered in the evening.

Additional courses may be taken from the following list and from any other graduate course list with the approval of the student's adviser: Admin. 500, 510, 560; Geog. 420; Ps.Sc. 407, 421, 430, 461, 470, 596, 597; P.Ad. 550, 551; R.Pl. 400; and So.Sc. 430, 440, 442, 443, and 590. Descriptions of those courses not given below may be found under the designated fields of study.

This program is offered only at the Capitol Campus. Details of application procedures should be requested from Admissions, The Capitol Campus, Middletown, PA 17057.

PSYCHOSOCIAL SCIENCE (PS SC)

- 401. SEMINAR IN PSYCHOSOCIAL SCIENCE (3)
- 407. SMALL GROUPS (3)
- 421. BEHAVIOR MODIFICATION (3)
- 430. SOCIAL JUDGMENT (3)
- 461. INTRODUCTION TO THE TECHNIQUES OF COUNSELING (3)
- 470. ADVANCED STATISTICAL AND DESIGN METHODS (3)

500. THEORIES AND ISSUES IN COMMUNITY PSYCHOLOGY (3) Contemporary issues in community psychology will be discussed within the framework of its development from clinical and social psychology.

511. PSYCHOPATHOLOGY IN A SOCIAL CONTEXT (3) Psychopathology in the context of other forms of social deviancy, with attention to both social and individual concomitants of deviancy.

521. PRACTICUM (3-9) Experience in a field setting with problems confronting both clients and social welfare agencies. Prerequisites: So.Sc. 510, 520.

530. RESEARCH (1-6) Supervised research on a master's paper. For degree candidates only.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

SOCIAL SCIENCE (SO SC)

- 440. THE CITY (3)
- 443. SOCIAL CONFLICT (3)

510. CHANGE PROCESSES (3) Social change as it takes place within institutions and communities.

520. **TECHNIQUES IN ACTION RESEARCH (3)** Methods for evaluating programmatic change. Pre-requisite: So.Sc. 320.
531. **THE FUNCTIONING NEIGHBORHOOD (3)** A study of small communities and techniques for observing them, coupled with field experience in participant observation of a specific neighborhood.
532. **COMMUNITY ORGANIZING: CONFLICT AND CHANGE (3)** The development of local issues and strategies for organizing around them.
533. **PROBLEMS OF THE DISENFRANCHISED (3)** Problems confronting minority or low-power groups, with an emphasis on the poor, blacks, and women.
541. **THE ORGANIZATION OF HUMAN SERVICES (3)** Divisions of labor among social agencies; internal and external factors affecting the ordering of priorities.
542. **SOCIAL STRATIFICATION (3)** Empirical and theoretical examinations of inequalities in wealth, prestige, and power.
543. **COMPLEX ORGANIZATIONS: CHANGE AND RESISTANCE (3)** Structure and function in large organizations and case studies of change.
590. **COLLOQUIUM (1-3)**

PUBLIC ADMINISTRATION (PUB A)

ROBERT J. MOWITZ, *Director of the Institute of Public Administration*
211 Burrowes Building

Degree Conferred: M.P.A.

Graduate Faculty: Senior Members LaPorte, Lee, and Mowitz.

Graduate Faculty: Associate Members McDavid, Poister, Stevens, and Webster.

All candidates take a core program consisting of seven seminars which cover the theoretical, methodological, and technological components of public management science. An additional 9 credits may be elected, permitting the student to focus upon such areas as general public administration, systems analysis, management information systems, urban systems administration, natural resources administration, human resources administration, or any other related substantive area. Course work may be taken at University Park or at the King of Prussia Graduate Center. Admission is authorized by the University Park program director.

Candidates for admission ordinarily have at least 12 credits of undergraduate work in the social sciences. Candidates for the degree may be required to take some courses without graduate credit in order to complete a major designed for their professional needs.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Scores from the Graduate Record Examination (aptitude test) and two letters of recommendation are required.

PUBLIC ADMINISTRATION (PUB A)

400. **INTRODUCTION TO THE AMERICAN ADMINISTRATIVE SYSTEM (3)** *Mr. Mowitz*
402. **METHODS OF PROGRAM ANALYSIS (3)** *Messrs. McDavid, Poister, and Webster*
403. **PUBLIC MANAGEMENT TECHNOLOGY (3)** *Messrs. LaPorte and Lee*
404. **URBAN MANAGEMENT (3)** *Messrs. Lee, McDavid, and Poister*
445. **ADMINISTRATIVE LAW (3)** *Messrs. Lee and Mowitz*
496. **INDEPENDENT STUDIES (1-12)**
497. **SPECIAL TOPICS (1-6)**

570. ADMINISTRATION IN MULTI-JURISDICTIONAL SYSTEMS (3) Analysis of multi-jurisdictional constraints on administration; design of strategies for developing and executing programs in a pluralistic institutional setting. *Messrs. LaPorte, Lee, McDavid, and Poister*
571. THEORY OF PUBLIC ADMINISTRATION (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice. *Messrs. Mowitz and Stevens*
572. (Pl.Sc. 572) INTERNATIONAL DEVELOPMENT ADMINISTRATION (3-6) The execution of foreign policies through national and international public and private organizations. *Mr. LaPorte*
573. (Pl.Sc. 573) COMPARATIVE PUBLIC ADMINISTRATION (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Mr. LaPorte*
574. (Pl.Sc. 574) SEMINAR IN THE ADMINISTRATION OF UNITED STATES FOREIGN AFFAIRS (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *Mr. LaPorte*
575. GOVERNMENT MANPOWER MANAGEMENT (3) Government personnel systems; current trends and problems; essentials of recruitment, classification and pay, ratings, supervision, training, and discipline. *Messrs. LaPorte, Lee, and Webster*
576. GOVERNMENT FISCAL DECISION MAKING (3) The role of the executive in fiscal planning; budget preparation; expenditure control; tax assessment and collection; investment of public funds. *Messrs. LaPorte, Lee, and Webster*
577. ORGANIZATION AND SYSTEMS MANAGEMENT (3) Principles of government organization; management surveys; work measurement; methods of achieving efficiency and economy. *Messrs. Mowitz and Stevens*
578. URBAN ADMINISTRATIVE SYSTEMS (3) Urban areas as administrative and policy systems; urban responses to problems of policy planning and implementation; approaches to urban analysis. *Messrs. Lee, McDavid, and Poister*
579. METHODS OF ANALYSIS AND MEASUREMENT IN PUBLIC ADMINISTRATION (3 per term, maximum of 6) Examination and application of analytical techniques for evaluating organizational performance and program effectiveness in government agencies. *Messrs. McDavid, Poister, and Webster*
580. INTERNSHIP IN PUBLIC ADMINISTRATION (1-6) *Mr. Mowitz*
581. PUBLIC MANAGEMENT INFORMATION SYSTEMS (3) Examination of the role of management information in public organizations; establishment of information requirements for public programs. Prerequisites: Pub.A. 571, 579. *Messrs. Stevens and Webster*
582. LEGISLATIVE MANAGEMENT AND OVERSIGHT FUNCTIONS (3) Examination of the role of the legislature in overseeing the executive; emphasis on financial and program analysis techniques and problems. *Mr. Mowitz*
584. RESEARCH SEMINAR IN PUBLIC ADMINISTRATION (1-6) Application of research methods to problems of organization, management, and policy in public agencies; preparation of research project and report. *Mr. Mowitz*
597. SPECIAL TOPICS (1-6) *Mr. Mowitz*

PUBLIC ADMINISTRATION (P ADM)

DANIEL M. POORE, *Chairman of the Public Administration Program*
The Capitol Campus, Middletown, PA 17057

Degree Conferred: M.P.A.

Graduate Faculty: Senior Members Gilmore and Masters.

Graduate Faculty: Associate Members Bresler, Chisholm, McKenna, Munzenrider, Poore, Skok, and Woodruff.

This interdisciplinary program is intended to prepare individuals for professional careers as administrators, project directors, or staff analysts in local, state, or federal government, health care organizations, welfare agencies, and other public service organizations. Applicants are expected to present adequate preparation in American government, introductory statistics, economics, accounting, computer methods, and the social and behavioral sciences or equivalent experience, or take work not for graduate credit in those areas.

The degree requires a minimum of 39 credits, including 9 credits of faculty-supervised field study in a public agency in the student's field of interest. The 9-credit field-study requirement may be waived for students who have at least three years of full-time professional experience in relevant administrative or staff work prior to graduation.

The 9-credit field-study course extends over three terms (about nine months) at 3 credits per term. It involves about twenty hours per week during two of the terms and about forty hours per week during the summer term. The field study is integrated with the other course work. The location of the Capitol Campus at the state capital of Pennsylvania provides excellent opportunities for field-study experiences in state government agencies, cities and smaller municipalities, county and federal agencies, large hospitals, Penn State's Milton S. Hershey Medical Center, and other professional and public-service organizations.

Full-time graduate work must be started in September, except under special circumstances. The time required to complete the program as a full-time student is normally sixteen months, including the field-study experience in a public agency.

Part-time students may start the program at the beginning of any term. They usually take one 3-credit course each term but may be permitted to take two courses during a term if their past academic performance is very good and their job situation permits. If a part-time student has sufficient professional work experience to waive the 9-credit field-study requirement, the graduate program can be completed in three years or less.

Students with a 3.00 junior-senior average will be considered for admission. Exceptions may be made for applicants with special backgrounds, abilities, and interests, or with professional experience. Applicants are expected to submit their aptitude scores on the Graduate Record Examination, a short essay outlining their career plans, and two letters of reference. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

COURSES*

ADMIN. 500. ADMINISTRATIVE THEORY (3)

ADMIN. 505. PERSONNEL MANAGEMENT (3)

ADMIN. 510. ORGANIZATION BEHAVIOR (3)

ADMIN. 515. LABOR MANAGEMENT RELATIONS (3)

ADMIN. 520. ADMINISTRATIVE MODELS (3)

ADMIN. 552. STATISTICAL RESEARCH METHODS (3)

P.ADM. 503. RESEARCH METHODS (1-3) Examination of research methodologies relevant to administration and public policy. Prerequisite: 3 credits in statistics.

*Descriptions of courses with Admin. designations can be found under that field of study.

P.ADM. 520. QUANTITATIVE MODELS FOR PUBLIC ADMINISTRATORS (3) Applications of quantitative models for the administrator's viewpoint. Explanation of the underlying models, assumptions made, questions explored, without mathematical detail. Prerequisite: one course in introductory statistics and completion of computer workshop

P.ADM. 530. FIELD STUDY IN PUBLIC ADMINISTRATION (1-3 per term, maximum of 9) Analysis and written reports on current problems/projects for a public agency in student's concentration area. Readings in concentration area. Prerequisite: permission of program chairman.

P.ADM. 532. URBAN GOVERNMENT (3) Administrative processes and policy problems associated with managing urban communities; political, intergovernmental, fiscal, structural, and analytical concepts in urban government.

P.ADM. 540. ADMINISTRATIVE POLICY FORMULATION (3) Analysis of administrative problems from a total organization viewpoint. Case studies of actual organizations are used for analysis.

P.ADM. 546. HEALTH PLANNING FOR PUBLIC ADMINISTRATION (3) Comprehensive planning and program planning for health services, facilities, and manpower; social, economic, and political considerations; methodological problems. Prerequisite: one course in introductory statistics and permission of program head.

P.ADM. 550. PROGRAM PLANNING AND EVALUATION (3) Analysis and evaluation of public programs and systems from the perspectives of policy development and administrative planning and management.

P.ADM. 551. ADMINISTRATION AND THE POLITICAL PROCESS (3) Analysis of the relationship of administration to the political processes that shape public policy formulation and execution.

P.ADM. 554. MASTER'S PROJECT (1-3) Student independently executes an applied professional or research project, involving the analysis of a management or a public policy problem. Prerequisite: P.Adm. 503.

P.ADM. 555. GOVERNMENTAL FISCAL DECISION MAKING (3) Nature, function, and technique of governmental budgeting viewed as mechanism for allocating resources among alternative public uses.

P.ADM. 556. STATE GOVERNMENT ADMINISTRATION (3) Study of structures, systems, processes, problems, and issues affecting state government administration; case studies, field observations, and research. Prerequisite: Admin. 500, P.Adm. 551.

P.ADM. 557. FEDERALISM AND INTERGOVERNMENTAL RELATIONS (3) Study of the impact of a federal system of government on the administration of public functions. National-state-local dimensions. Prerequisite: P.Adm. 551.

P.ADM. 558. LEGISLATIVE PROCESSES (3) Legislatures in American government emphasizing comparative state legislatures: constitutional patterns; organization, administration; interaction with bureaucracy, constituencies, and organized interests. Prerequisite: Admin. 500, P.Adm. 551.

P.ADM. 590. COLLOQUIUM (1-3)

P.ADM. 596. INDIVIDUAL STUDIES (1-6)

P.ADM. 597. SPECIAL TOPICS (1-6)

RECREATION AND PARKS (RC PK)

KARL G. STOEDEFALKE, *Associate Dean for Academic Affairs*
274 Recreation Building

Degrees Conferred: M.S., M.Ed.

Graduate Faculty: Senior Members Harris, Kando, Lundegren, Stodefalk, and van der Smisen.

Graduate Faculty: Associate Members Christiansen, Elliott, Farrell, Godbey, Guadagnolo, and Knopf.

The graduate program is designed to prepare students for administrative, supervisory, research, and teaching positions in public recreation and park systems, in colleges and universities, in voluntary agencies, and in institutions.

The program is oriented to meet the specific needs and research interests of the candidate. Students may pursue interests in the community, including public park and recreation systems, quasi-public and voluntary agencies, and private enterprises; institution and community-oriented therapeutic settings concerned with many different disabilities and utilizing a variety of activity modalities; and camping and outing activities, park planning, interpretive services, outdoor education, and outdoor recreation services.

The master's degree may be earned in the major program of recreation and parks. At the doctoral level, the Ph.D. and D.Ed. may be earned with a specialization in recreation and parks within the physical education major. Detailed information is available from the department.

For admission to the graduate program, a bachelor's or master's degree is required, preferably in recreation and parks. Candidates from other majors are welcome to apply; however, additional coursework is required. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

RECREATION AND PARKS (RC PK)

- 420. OUTDOOR RECREATION (3)
 - 421. WATER-ORIENTED OUTDOOR RECREATION (3)
 - 425. INTERPRETIVE SERVICES (3)
 - 427. OUTDOOR RECREATION PROGRAM SERVICES (3)
 - 429. INTERPRETIVE PLANNING (2)
 - 430. OUTDOOR EDUCATION: METHODS AND MATERIALS (3)
 - 433. EVALUATION IN RECREATION AND PARKS (3)
 - 440. ADMINISTRATION OF ENVIRONMENTAL PROGRAM OPERATIONS (3)
 - 450. RECREATION ISSUES (1)
 - 456. RECREATION PROGRAM ORGANIZATION (3)
 - 458. DYNAMICS OF RECREATION GROUPS (3)
 - 460. LEGAL ASPECTS OF RECREATION AND PARKS (3)
 - 462. (Soc. 462) THE SOCIOLOGY OF LEISURE (3)
 - 465. ADMINISTRATION OF RECREATION AND PARKS (3)
 - 470. PARK MANAGEMENT (3)
 - 475. THERAPEUTIC RECREATION IN THE COMMUNITY (3)
 - 477. THERAPEUTIC RECREATION SERVICES (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
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- 500. (PH.ED. 500) INDIVIDUAL STUDY AND RESEARCH PROJECTS (1-10) Prerequisite: Rc.Pk. 530.
 - 515. PROGRAM DEVELOPMENT AND SUPERVISION (3) Critical analysis of the individual, political, and societal determinants of recreation programming; demonstration projects; evaluative procedures, research functions in programming. Prerequisite: Rc.Pk. 456.
 - 520. SEMINAR IN ENVIRONMENTAL EDUCATION ADMINISTRATIVE PROBLEMS (3) Focus upon use of

- the outdoors by special groups in resident and nonresident settings. Prerequisite: Rc.Pk. 230 or 430.
522. SEMINAR IN CURRICULUM, SUPERVISION AND EVALUATION OF ENVIRONMENTAL EDUCATION PROGRAMS (3) Prerequisite: Rc.Pk. 430.
525. BEHAVIORAL PATTERNS OF THE OUTDOOR RECREATIONIST (3) Patterns of time and space use; user characteristics; meaning of participation; facilitation of environment-use enhancement. Prerequisite: Rc.Pk. 420.
530. (Hl.Ed. 530, Ph.Ed. 530) RESEARCH TECHNIQUES IN HEALTH AND PHYSICAL EDUCATION AND RECREATION (3) Research techniques, including methods, research design, techniques for data collection, as applied to relevant problems in the health education field.
533. RECREATION STUDIES, SURVEYS, AND APPRAISALS (3) Advanced research procedures related to special recreation and park problems. Prerequisites: Rc.Pk. 530 and 3 credits in statistics.
540. PUBLIC AND PRIVATE RECREATION LANDS AND WATERS (3) Public and private roles and interactions, allocation of resources, use policies, open space concepts, private enterprise developments, legal controls.
542. ENVIRONMENTAL LAW (3) Legislative, judiciary, administrative processes-roles; citizen action; legal concepts, litigation and enforcement tactics for protection and enhancement of natural environment.
550. SEMINAR IN RECREATION AND PARKS (1-6)
560. ADMINISTRATIVE PROBLEMS OF RECREATION AND PARKS (3) Special problems of recreation and park departments; legal powers and liability; departmental organization, financing, personnel policies, and staff development. Prerequisite: Rc.Pk. 465.
570. CONCEPTUAL BASES FOR THERAPEUTIC RECREATION (3) Issues in the application of concepts in therapeutic recreation from a multidisciplinary perspective; evaluation and research. Prerequisite: Rc.Pk. 477.
595. PHILOSOPHICAL AND SOCIAL BASES OF RECREATION (3) Philosophical and social bases of recreation; analysis of critical issues of recreation for philosophical and social implications.

REGIONAL PLANNING (R PL)

HAYS B. GAMBLE, *Chairman of the Graduate Program in Regional Planning*
213 Willard Building

Degree Conferred: M.R.P.

Graduate Faculty: Senior Members J. Coyle, Gamble, Larson, Lee, J. Miller, Newman, and Young.

Graduate Faculty: Associate Members Erickson, Loukissas, and B. Myers.

The graduate program in regional planning emphasizes a multidisciplinary approach to the planning process for multijurisdictional areas, both urban and rural. The program's basic intent is to develop technically competent regional planners who are aware of the social, political, economic, and physical purposes of planning. A strong feature of the program is that it provides a broad opportunity for a student to pursue a sequence of courses in a special option or to earn a concurrent degree in a planning-related discipline. A nonthesis option is available for the MRP degree. Graduates of the program are employed in planning agencies in all levels of government and in private industry.

For admission a student must have had at least one course in each of the following areas: statistics, economics, ecology, sociology, public administration or political science, and physical geography or cartography. Applicants must submit scores on the Graduate Record Examination with their applications. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered up to the number of spaces available. Exceptions to the 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

REGIONAL PLANNING (R PL)

- 400. PRINCIPLES OF REGIONAL PLANNING (3-6)
- 410. PLANNING PROGRAMS (3)
- 440. PROBLEMS IN COMMUNITY AND REGIONAL PLANNING (1-9)

- 502. REGIONAL SYSTEMS ANALYSIS (3-6) Spatial structure of regional and interregional systems; theories of regional development; spatial measures of location, density, central tendency, and dispersion.
- 503. THEORY AND METHOD OF PLANNING (3) Analysis of normative models of planning processes: social, economic, political, and behavioral assumptions, and methodological problems of evaluatory planning performance.
- 510. PLANNING TECHNIQUES AND ANALYSIS I (3) Regional socioeconomic structure, problems, and factors in planning; data collection, analysis, and implications.
- 520. PLANNING TECHNIQUES AND ANALYSIS II (3) Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.
- 530. PLANNING TECHNIQUES AND ANALYSIS III (3) Effects of political, cultural, and physical factors on planning.
- 540. PROBLEMS IN REGIONAL PLANNING (1-9) Planned individual projects involving library, laboratory (studio), or field work.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

RELIGIOUS STUDIES (RL ST)

YOSHIO FUKUYAMA, *Head of the Department*
1001 Liberal Arts Tower

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Cherry, Fukuyama, Harrison, Harshbarger and Prebish.

Graduate Faculty: Associate Members Cohn, Lowrie, Stephens, and Vastyan.

The emphasis of this program is on the comprehensive understanding of the various facets of religion in American culture. A broad cross-disciplinary scope is encouraged in substantive areas with particular emphasis on the development of religious thought and movements and the relationships between religion and society. The student will share responsibility with the faculty in shaping a program.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

Applications will be evaluated on the basis of the quality of undergraduate, graduate, or professional records and on the basis of the candidate's clarity of understanding and interest in the specific emphases of the program. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Graduate Record Examination scores, letters of recommendation, and a statement of the applicant's career goals and academic interests are required.

RELIGIOUS STUDIES (RL ST)

- 401. SEMINAR IN COMPARATIVE RELIGION (3-6)

- 402. SEMINAR IN CONTEMPORARY RELIGIOUS THOUGHT (3-6)
- 408. HINDUISM (3)
- 409. BUDDHISM (3)
- 411. SEMINAR IN JEWISH STUDIES (3)
- 421. CULTURE AND RELIGIOUS REFORM (3)
- 422. RELIGION AND AMERICAN CULTURE (3 per term, maximum of 6)
- 430. SEMINAR IN RELIGIOUS ETHICS (3)
- 438. (SOC. 438) RELIGION AND URBAN SOCIETY (3)
- 461. (SOC. 461) SOCIOLOGY OF RELIGION (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 500. THEORIES OF RELIGION (3-6) Cross-disciplinary study of two or more systematic theories of religion: anthropological, phenomenological, philosophical, psychological, sociological, or theological.
- 502. STUDIES IN COMPARATIVE RELIGIONS (3-6) Cross-cultural comparative studies of two or more world religions.
- 505. SEMINAR IN ASIAN RELIGIONS (3-6) Studies in selected Asian religions.
- 521. ISSUES IN WESTERN RELIGION (3-6) Seminar. Study of selected issues in Western religion.
- 522. ADVANCED STUDIES IN AMERICAN RELIGION (3-6) In-depth inquiry into either a period, a movement, or a topic of American religion.
- 524. MAJOR WESTERN RELIGIOUS THINKERS (3-6) Systematic inquiry into the religious thought of major Western religious thinkers.
- 530. RELIGION AND SOCIETY (3-6) Studies of mutual influences and effects of religion and secular phenomena.
- 532. RELIGION AND SOCIAL PROBLEMS (3-6) Study of a selected social issue, or constellation of issues, with analysis of its religious and normative dimensions.
- 536. RELIGIOUS STRUCTURES AND PROCESSES (3-6) Study of the relationship between religion as social structure and as a dynamic social function.
- 539. ADVANCED STUDIES IN RELIGIOUS ETHICS (3-6) A systematic study of the structure and essential themes of ethics of religious institutions and thinkers.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

RURAL SOCIOLOGY (R SOC)

JOHN W. MALONE, JR., *Head of the Department of Agricultural Economics and Rural Sociology*
6A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Bealer, Brown, Crawford, Malone, Stokes, Warland, Wilkinson, and Willis.

Graduate Faculty: Associate Members Crider, Heasley, Leadley, and Rodefald.

All degree programs emphasize a comprehensive understanding of the various facets of societal organization pertinent to the rural sector. While scope is encouraged, areas of special interest and

research include: consumer behavior, instigated social change, community structure, leadership, population, rural health, rural community services, the structure of agriculture, and the ecology of rurality in industrialized and urbanized society. All students are required to have training in sociological theory, statistics, and research methods.

There is no foreign language requirement for the Ph.D. degree; the student is expected to substitute such courses and instruction necessary to generate superior capabilities of inquiry into an analysis of basic and/or applied rural sociological problems.

Prerequisites for the master's program include 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If the entering student does not have these prerequisites, they must be made up at the University during the early part of the master's program.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

RURAL SOCIOLOGY (R SOC)

- 402. CONSUMER BEHAVIOR AND THE AGRICULTURAL INDUSTRY (3) *Mr. Herrmann*
- 405. LEADERSHIP FOR SOCIAL CHANGE (3) *Mr. Heasley*
- 425. POVERTY ANALYSIS: PEOPLE AND PROGRAMS (3) *Mr. Van Horn*
- 444. THE RURAL TRANSITION IN AMERICAN SOCIETY (3) *Mr. Leadley*
- 452. RURAL ORGANIZATION (3) *Mr. Wilkinson*
- 456. RURAL COMMUNITY SERVICES (3) *Mr. Leadley*
- 459. RURAL SOCIAL PSYCHOLOGY (3) *Mrs. Willits*
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. DEVELOPMENT OF RURAL SOCIOLOGY (2) Historical development with emphasis on American rural sociology. Odd years. *Mr. Crider*
- 502. ADVANCED RURAL SOCIOLOGY (3) Structure and functioning of rural society; evaluation of theoretical systems. Even years. *Mr. Bealer*
- 510. RURAL MIGRATION (2) Rural migration research and theory; application to governmental and community problems. Odd years. *Mr. Stokes*
- 513. SOCIOLOGY OF CONSUMER BEHAVIOR (2) Sociological theory and research pertaining to consumer behavior. Odd years. *Mr. Warland*
- 514. VALUES IN RURAL SOCIETY (2) Values as dynamic forces in rural society. *Mr. Bealer*
- 515. EXTENSION ORGANIZATION AND METHODS (3) Agricultural and home economics extension as a social system, with emphasis on techniques of organization and program development. *Mrs. Thompson*
- 516. CHANGE IN RURAL SOCIETY (2) Social change in rural society, emphasizing prediction and control of the change process. Even years. *Mr. Crider*
- 551. RURAL SOCIOLOGY SEMINAR (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.
- 596. INDIVIDUAL STUDIES (1-6)

SCHOOL PSYCHOLOGY (S PSY)

JOSEPH L. FRENCH, *Chairman of the Committee on School Psychology*
104 CEDAR Building

Degrees Conferred: D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members DiVesta, French, Gorlow, Horan, Keat, Salvia, Weener, and Withall.

Graduate Faculty: Associate Member Snyder.

This intercollege program is based primarily on courses in counselor education, educational psychology, psychology, and special education. In addition, courses are often drawn from individual and family studies, cultural foundations of education, educational administration, and curriculum and instruction.

The objective is to develop a psychologist who is interested in and knowledgeable about education and psychology in the school setting. The school psychologist must utilize professional skill and knowledge about children and youth to make contributions which are meaningful to, and utilized by, teachers, other school personnel, and parents. The development of competences needed by a fully qualified school psychologist requires at least the education represented by a doctoral degree. Only those students who anticipate a doctoral degree will be admitted. Exceptions may be made for students with special backgrounds, abilities, and interests. Students are selected within the limitations of program facilities. Priority is given to applicants with work experience with children.

An undergraduate major emphasizing work in psychology and/or education is preferred, but students with fewer than 15 upper-division credits in psychology, educational psychology, or special education may be admitted with limited deficiencies to be fulfilled concurrently with their graduate work. Requirements for admission include a minimum junior-senior scholastic average of 2.85 or, for applicants with master's degrees, a minimum of one-third of graduate credits of A quality; satisfactory recommendations from two or more professors, preferably psychologists; and 500 or higher on the general sections of the Graduate Record Examination, 58 or higher on the Miller Analogies Test, and/or 35 or higher on the Quantitative Evaluative Device.

Practicum facilities, in addition to those in nearby public schools, include the Center for Educational Diagnosis and Remediation, the School Psychology Clinic, the Speech Pathology and Audiology Clinic, the Reading Center, the Psychology Clinic, and the Campus Demonstration School for handicapped children. Facilities for work with children are also available through other academic units, as well as through assistantship assignments.

SCHOOL PSYCHOLOGY (S PSY)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

500. PROFESSIONAL ISSUES IN SCHOOL PSYCHOLOGY (1-3) Orientation to the field through study of unique problems, current issues, ethical and legal matters, unique cases, and research projects.

504. PRACTICUM IN SCHOOL PSYCHOLOGY (1-6) Clinical experience with children under supervision in a variety of settings requiring service, including practice in synthesizing data and observations.

508. INTERNSHIP IN SCHOOL PSYCHOLOGY (1-10) Long-term placement in settings providing work for school psychologists with children, parents, teachers, administrators, and service agencies, under supervision.

510. SUPERVISION OF SCHOOL PSYCHOLOGISTS (1-10) Program supervision and professional leadership in university clinics and school systems. Prerequisite: S.Psy. 504.

559. (Psy. 559) THE INDIVIDUAL PSYCHOLOGICAL EXAMINATION (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

596. INDIVIDUAL STUDIES (1-6)

SLAVIC LANGUAGES AND LITERATURES (S L L)

WILLIAM R. SCHMALSTIEG, *Head of the Department of Slavic Languages*
N-440 Burrowes Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members Birkenmayer, Magner, Paternost, and Schmalstieg.

Graduate Faculty: Associate Member Gebhard.

Opportunities for specialization in literature or linguistics are available. A minimum requirement for admission is an undergraduate major in Russian or its equivalent.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The department prefers that M.A. candidates in this major submit a term paper rather than a thesis.

RUSSIAN (RUS)

- 426. DOSTOEVSKY (3)
- 427. TOLSTOY (3)
- 430. METHODS AND MATERIALS FOR TEACHING RUSSIAN (3)
- 450. HISTORY OF THE RUSSIAN LANGUAGE (3)
- 460. LINGUISTIC ANALYSIS OF CONTEMPORARY RUSSIAN (3)
- 495. PROBLEMS IN RUSSIAN (3-9)

*1G. TECHNICAL RUSSIAN FOR GRADUATE STUDENTS (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

*2G. RUSSIAN TEXTS (3) Development of skill in translating Russian texts in the sciences and social sciences. Prerequisites: Rus. 5 or 1G.

501. READINGS IN RUSSIAN LITERATURE (3-6) Prerequisite: Rus. 204.

525. PUSHKIN (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

540. EIGHTEENTH-CENTURY RUSSIAN LITERATURE (3) Study of the major writers and literary developments in this period of the secularization and modernization of Russian literature.

542. SEMINAR IN SOVIET LITERATURE (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.

570. OLD RUSSIAN LITERATURE (3) Analysis of Russian literary monuments in the original, 1100-1700. Prerequisite: Slav. 550.

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

SLAVIC (SLAV)

500. BIBLIOGRAPHY AND RESEARCH TECHNIQUES (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literatures.

510. STRUCTURE OF THE SOUTH SLAVIC AND WEST SLAVIC LANGUAGES (3-12; 3 credits per language) Linguistic analysis of a particular South Slavic (Bulgarian, Macedonian, Serbo-Croatian, Slovenian) or West Slavic (Czech, Lusatian, Polish, Slovak) language. Prerequisite: Rus. 460 or one graduate course in linguistics.

*No graduate credit is given for this course.

550. OLD CHURCH SLAVIC (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

560. THEORY AND TECHNIQUE IN SLAVIC LINGUISTICS (3-6) Analysis of the relationship of the Slavic languages; consideration of particular linguistic problems within one or more of the languages.

SOCIAL STUDIES (SO ST)

HUGO A. MEIER, *Chairman of the Committee on Social Studies*
612 Liberal Arts Tower

Degree Conferred: M.Ed.

This program provides advanced study in history and the social sciences for secondary school teachers. Candidates select a minimum of 24 credits representing at least four of the following areas, with an emphasis of 9 to 12 credits in one of them: economics, history, human geography, labor studies, political science, rural sociology, and sociology. A minor field of at least 6 credits in educational foundations is required.

For admission a student must have had solid preparation in the basic courses in economics, history, political science, and sociology and should have had some advanced undergraduate work in at least one of these areas. Also required are 18 credits in education and related psychology, and certification for teaching social studies. Ideally, the student should have had teaching experience in this field as well.

Students who present a 2.50 junior-senior average and a 3.00 average in the social studies areas will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

SOCIOLOGY (SOC)

ROLAND J. PELLEGRIN, *Head of the Department*
201B Liberal Arts Tower

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Buck, DeJong, Faulkner, Matson, Pellegrin, Simirenko, Snyder, Theodorson, and Westby.

Graduate Faculty: Associate Members Austin, Bord, Clemente, Clogg, Gelman, Humphrey, Johnson, Meahl, Mitchell, Raphael, Sauer, Sim, Steffensmeier, and Taylor.

The M.A. and Ph.D. programs center on training in basic social theory and methodology and the empirical findings in the various areas of sociology. Departmental offerings cover a wide range, including courses and seminars in most fields of specialization in the discipline. The program is designed with considerable flexibility so that students can adapt course work outside the department to their individual interests and goals. One foreign language and work in computer science, philosophy of science, or mathematics may be used to fulfill the Ph.D. degree communication and foreign language requirement. All first-year students who intend to pursue doctoral work are expected to earn an M.A. degree in their normal progress to the Ph.D. The department offers two options leading to the M.A. For the M.A. preparatory to the Ph.D., students must write a thesis and pass qualifying examinations. For the terminal M.A., students must submit a professional paper approved by a committee of three faculty members.

Undergraduate training in sociology is expected. Students of ability who are deficient in undergraduate preparation may be accepted with provisions to make up course deficiencies in the early part of their graduate program. Candidate selection is based on the following information: quality undergraduate academic performance, above-average Graduate Record Examination scores, letters of recommendation, an essay giving the applicant's interests, goals, and purposes for graduate work in sociology, and submission of written work from the student's undergraduate program, such as a term paper. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

The population issues program is a course of study focusing on the social, economic, and geographic policy-related issues arising from the dynamics of population trends, especially in developed nations. In addition to departmental admission requirements, the population issues committee evaluates the student's interest and aptitude for the training program, which consists of a minimum of 21 credits of interdisciplinary course work in population.

Other areas of study related to sociology, such as rural sociology, community development, cultural anthropology, developmental psychology, and political behavior, are offered in other departments of the University.

Special departmental research and training facilities include the Liberal Arts Data Laboratory, small groups research laboratory, and a sociology reference library. Additional University facilities used by sociology faculty and graduate students include the Computation Center, the Inter-University Consortium of Political Research, the Institute of Public Administration, the Institute for Research in Human Resources, and the Center for the Study of Religion and Human Resources.

SOCIOLOGY (SOC)

- 400. ADVANCED GENERAL SOCIOLOGY (3)
- 401. SOCIAL INSTITUTIONS (3)
- 403. ADVANCED SOCIAL PSYCHOLOGY (3)
- 404. SMALL GROUPS (3)
- 406. SOCIOLOGICAL ANALYSIS OF DEVIANCE (3)
- 407. CORRELATES OF POVERTY (3)
- 408. SOCIAL ECOLOGY (3)
- 410. SOCIAL PSYCHOLOGY OF HEALTH (3)
- 412. CRIME AND SOCIAL CONTROL (3)
- 413. METHODS AND TECHNIQUES OF SOCIAL RESEARCH (3)
- 415. THE URBAN COMMUNITY (3)
- 416. (C.F.Ed. 416) SOCIOLOGY OF EDUCATION (3)
- 417. INTRODUCTION TO SOCIAL WORK PRACTICE (3)
- 418. THE DEVELOPMENT OF SOCIAL THOUGHT (3)
- 419. RACE RELATIONS (3)
- 420. FIELD WORK IN SOCIAL WELFARE (3-6)
- 421. SOCIAL GROUP WORK (3)
- 422. HISTORY OF SOCIOLOGICAL THEORY (3)
- 423. SOCIAL DEMOGRAPHY (3)
- 424. SOCIAL CHANGE (3)
- 426. PUBLIC WELFARE POLICY AND SERVICES (3)
- 427. SOCIAL CASEWORK (3)
- 429. SOCIAL STRATIFICATION (3)
- 430. FAMILY IN CROSS-CULTURAL PERSPECTIVE (3)
- 431. SOCIAL WORK PROCESSES (3)
- 432. COLLECTIVE BEHAVIOR (3)
- 433. SOCIAL WORK PRACTICE ANALYSIS (2)
- 434. SOCIAL WELFARE POST-PLACEMENT SEMINAR (1)
- 435. SOCIAL GERONTOLOGY (3)
- 436. (Journ. 436) SOCIOLOGY OF OPINION FORMATION (3)

438. (RI.St. 438) RELIGION AND URBAN SOCIETY (3)
444. COMPLEX ORGANIZATIONS (3)
446. POLITICAL SOCIOLOGY (3)
447. (M.E.R. 447) ENVIRONMENTAL SOCIOLOGY (3)
450. COMMUNITY ORGANIZATION (3)
453. (Anthy. 453) PRIMITIVE RELIGION (3)
454. (L.S. 454) INDUSTRY AND THE COMMUNITY (3)
455. (L.S. 455) THE SOCIOLOGY OF WORK (3)
457. FIELD WORK IN WORK ORGANIZATIONS (1-6)
458. SOCIAL WORK IN THE COMMUNITY (3)
461. (RI.St. 461) SOCIOLOGY OF RELIGION (3)
462. (Rc.Pk. 462) THE SOCIOLOGY OF LEISURE (3)
470. INTERMEDIATE SOCIAL STATISTICS (4)
473. METHODS OF DEMOGRAPHIC ANALYSIS (3-6)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
499. FOREIGN STUDY IN SOCIOLOGY (2-6)

500. SEMINAR IN GROUP THEORY (1-3) The group as a unit of social structure and action.
502. THEORIES OF SOCIETY (3) Past and present theories of the overall structure and processes of societal functioning.
503. RESEARCH SEMINAR IN SOCIAL PSYCHOLOGY (3-6) Design and conduct of research in areas of mutual interest in social psychology.
- 504-505. CURRENT SOCIAL THEORY (3 each) Current contributions to social theory; their relations to each other and to the larger theoretical structure.
506. SEMINAR IN SOCIOLOGICAL THEORY (3-9)
507. INTRODUCTION TO GRADUATE STUDY IN SOCIOLOGY (1) Required of all incoming graduate students in sociology.
509. SEMINAR IN MEDICAL SOCIOLOGY RESEARCH (1-6) Early and current classics of medical sociology research critically reviewed; limitations and possibilities; needs of society; available resources. Prerequisites: Soc. 410, 413.
510. FIELD WORK IN SOCIOLOGY (1-6)
511. READINGS IN THE SOCIOLOGY OF HEALTH (1-6) Independent pursuit of existing knowledge in fields of the student's interest, in reference books, monographs, journals. Bibliography preparation. Prerequisite: Soc. 410.
512. SEMINAR IN DEVIANT BEHAVIOR (2-6) Advanced sociological study of crime, juvenile delinquency, mental disorders, suicide, drug addiction, prostitution, and other social deviation. Prerequisite: 6 credits in sociology.
- 513-514. SOCIOLOGICAL METHODS (3 each) Critical review of methodological issues; philosophy of science; research designs; analysis and interpretation of findings. Prerequisites: Soc. 413, 470.
515. SEMINAR IN COMMUNITY STUDIES (3)
523. SEMINAR IN POPULATION THEORY AND POLICY (1-6) Critical review of multidisciplinary population research with an emphasis on its relation to policy issues. Prerequisite: 3 credits in population or human ecology.
525. SEMINAR IN SOCIOLOGY (1-6) Research problems in theoretical and applied sociology.
530. RESEARCH ON MARRIAGE AND THE FAMILY (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.
- 532-533-534. SOCIAL RELATIONS (3 each) Critical appraisal of major social-psychological prob-

lems confronting modern man; emphasis on formulation of fruitful research projects and their evaluation. Prerequisite: 15 graduate credits in social science departments or psychology, including a course in statistics.

535. SEMINAR IN GERONTOLOGY (2-6) A structural-functional analysis of current research dealing with the relationships between institutional structure, age grading, and social behavior.

546. SEMINAR IN POLITICAL SOCIOLOGY (3 per term, maximum of 6) Research and analysis of contemporary issues in political sociology. Prerequisite: 3 credits in statistics.

551. COMPARATIVE INSTITUTIONS AND SYSTEMS OF STRATIFICATION (3) Critical appraisal of major problems in comparative sociology, including comparative studies of Western, socialist, and Third World countries.

555. INDUSTRIAL SOCIOLOGY (3) Research methods and techniques in industrial sociology; current research, unexplored areas.

572-573. SOCIAL STATISTICS (3 each) Application of parametric and nonparametric statistical methods to sociology; sampling; computer data processing techniques. Prerequisites: Soc. 470 and 3 credits in research methods.

574-575. QUANTITATIVE SOCIOLOGY (3 each) Problems and issues in the mathematical and quantitative aspects of sociology. Prerequisites: Soc. 413, 470.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

SOLID STATE SCIENCE (S S S)

ROBERT E. NEWNHAM, *In Charge of Graduate Programs in Solid State Science*
169 Materials Research Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barsch, Cross, Dachille, Das, Fonash, Henisch, Hummel, Kline, Knox, Macmillan, Madjid, McKinstry, Mulay, Newnham, D. Roy, R. Roy, Spear, Stubican, Thrower, Tsong, Tressler, Vastola, Vedam, Walker, and W. White.

Graduate Faculty: Associate Members Biggers, Coleman, Harrison, Johnson, and McCarthy.

The aim of this intercollege program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the necessary fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The program of courses taken by a student majoring in this program must necessarily cut across two or more disciplines. The relevant subject matter has been grouped into four areas: (1) the structure of solids (crystal chemistry and structure determination); (2) theory related to the solid state (physics, chemistry, and mechanics); (3) properties of solids (optical, electrical, magnetic, mechanical, thermal, and chemical); and (4) reactions of solids (phase equilibria, reaction mechanisms, reaction kinetics, and surface reactions).

The course work of all students will normally include the "core program" as periodically redefined. Recommended course sequences for each year for students with different undergraduate backgrounds are prepared by the chairman and are available from the student's adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two

foreign languages, or by one foreign language together with courses from other designated areas.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included in it mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. The applicant should be interested specifically in an interdisciplinary program of study and research. Thesis research on various aspects of the solid state may be conducted in the Materials Research Laboratory, the Applied Research Laboratory, or in appropriate departments in the Colleges of Earth and Mineral Sciences, Engineering, and Science. The experimental facilities for research in several aspects of materials science and engineering are exceptional.

S.S.S. 590 (Colloquium) and S.S.S. 596 (Individual Studies) will be offered once each year to promote the interdisciplinary aspects of solid state science. Further information will be available from the Solid State Science office.

In addition, students may select appropriate course work from any engineering or science department. The following list includes those which are most commonly taken to satisfy core curriculum requirements: Structure of Solids: Mat.Sc. 408, 512, 514. Solid State Theory: Metal. 508, 509; Phys. 410. Physical Properties of Solids: Cer.Sc. 508; Mat.Sc. 542; Phys. 412, 413, 524. Chemical Reactions in Solids: G.M. 519; Mat.Sc. 416.

SOLID STATE SCIENCE (S S S)

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

SPANISH (SPAN)

MARTIN S. STABB, *Head of the Department of Spanish, Italian, and Portuguese*
N-352 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Brentin, Dalbor, Halsey, Lima, Lyday, Moser, Pérez, Stabb, Sturcken, and Triolo.

Graduate Faculty: Associate Members Higgs, Peavler, Weiss, and Zamora.

The minimum requirement for admission will normally be 24 credits of post-intermediate work in Spanish language and literature. The department may waive the requirement of a thesis for M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPANISH (SPAN)

400. ADVANCED GRAMMAR AND COMPOSITION (3)

404. THE EVOLUTION OF SPANISH (3)

410. ADVANCED ORAL EXPRESSION AND COMMUNICATION (3)

413. THE TEACHING OF SPANISH (4)
 414. SPANISH PHONOLOGY (3)
 415. SPANISH MORPHOLOGY AND SYNTAX (3)
 416. OLD SPANISH LITERATURE (3)
 426. THE GOLDEN AGE (3)
 427. DRAMA OF THE GOLDEN AGE (3)
 439. DON QUIJOTE (3)
 459. THE GENERATION OF 1898 (3)
 472. THE CONTEMPORARY SPANISH AMERICAN NOVEL (3)
 475. INTRODUCTION TO LATIN AMERICAN LITERATURE (3)
 476. INTRODUCTION TO LATIN AMERICAN LITERATURE (3)
 477. THE LITERATURE OF MEXICO (3)
 480. LITERATURE OF ARGENTINA (3)
 482. SPANISH LYRIC POETRY (3)
 483. SPANISH DRAMA OF THE NINETEENTH CENTURY (3)
 485. SPANISH DRAMA OF THE TWENTIETH CENTURY (3)
 487. THE SPANISH NOVEL OF THE NINETEENTH CENTURY (3)
 489. THE SPANISH NOVEL OF THE TWENTIETH CENTURY (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
 499. FOREIGN STUDY IN SPANISH (3)
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502. THEORY AND TECHNIQUES OF TEACHING SPANISH (1-3) Audio-lingual orientation. *Mr. Higgs*
 503. METHODS AND BIBLIOGRAPHY IN SPANISH (1-3) Methods of research; evaluation of sources and materials.
 505. OLD SPANISH: PHONOLOGY, MORPHOLOGY, AND SYNTAX (3) *Mr. Sturcken*
 506. HISTORY OF THE SPANISH LANGUAGE (3) *Mr. Sturcken*
 507. HISPANO-ROMANCE LINGUISTICS (3) *Mr. Sturcken*
 510. SPANISH DESCRIPTIVE LINGUISTICS: PHONOLOGY (3) *Mr. Dalbor*
 511. SPANISH TRANSFORMATIONAL-GENERATIVE LINGUISTICS (3) *Mr. Dalbor*
 514. HISPANIC DIALECTOLOGY (3) Early fragmentation among the peninsular dialects; origins and descriptive analysis of the American dialects; Judeo-Spanish. *Messrs. Dalbor and Sturcken*
 516. MEDIEVAL SPANISH LITERATURE (3 per term, maximum of 9) Topics vary: *juglaria* and *clerecía*, emergence of lyric and brief narrative; history and didacticism; origins of novel; balladry; fifteenth-century innovations.
 518. EL LIBRO DE BUEN AMOR (3) *Mr. Sturcken*
 521. THE CELESTINA AND THE LITERATURE OF THE SPANISH PRE-RENAISSANCE (3) Chief trends and works of the period of the Catholic monarchs, with special emphasis on Fernando de Rojas' masterpiece *La Celestina*. *Messrs. Pérez and Triolo*
 525. SPANISH RENAISSANCE AND GOLDEN AGE POETRY (3) Lyric poetry, epic poetry, and balladry. *Mr. Triolo*
 527. SIXTEENTH-CENTURY SPANISH PROSE (3) The major prose writers of the Spanish sixteenth century. *Messrs. Brentin and Pérez*
 528. SEVENTEENTH-CENTURY SPANISH PROSE (3) Various types of novels of the seventeenth century, with special emphasis on the picaresque, didactic literature, histories. *Messrs. Brentin and Pérez*
 538. THEATRE OF LOPE DE VEGA AND HIS CYCLE (3) Major works of Lope de Vega, Tirso de Molina, Guillén de Castro, Mira de Amescua, and others. *Mr. Pérez*

539. THEATRE OF CALDERÓN DE LA BARCA AND HIS CYCLE (3) Major works of Calderón de la Barca, Rojas Zorrilla, Agustín Moreto, and others. *Mr. Pérez*
540. CERVANTES: THE QUIJOTE (3) A careful reading of Cervantes' famous novel and consideration of some of the corpus of criticism on the novel. *Messrs. Brentin and Pérez*
541. CERVANTES: OTHER WORKS (3) Cervantes' major works, excluding the *Quijote*. *Messrs. Brentin and Pérez*
544. SPANISH ROMANTICISM (3) The major authors and works of peninsular romanticism, including poetry, drama and prose. *Miss Halsey and Mr. Lima*
550. SPANISH REALISM (3) The major figures of the period with special emphasis on Pérez Galdós. *Mr. Zamora*
554. GENERATION OF 1898: PROSE (3) Selected essays and novels from the works of Gánivet, Pidal, Unamuno, Maeztu, Azorín, Lanza, Baroja and Valle-Inclán. *Messrs. Lima and Zamora*
555. GENERATION OF 1898: POETRY AND DRAMA (3) Selected poems and plays from the works of Antonio and Manuel Machado, Benavente, Grau, Azorín, Valle-Inclán, Unamuno, Baroja and others. *Mr. Lima*
560. THE CONTEMPORARY NOVEL IN SPAIN (3) The novel since 1941: Cela, Laforet, Zunzunegui, Suárez Carreño, Matute, and others. *Messrs. Brentin and Zamora*
563. CONTEMPORARY DRAMA IN SPAIN (3) The drama from 1898 to the present day: Benavente, Valle-Inclán, García Lorca, Casona, Buero Vallejo, Sastre, and others. *Miss Halsey and Mr. Lima*
566. CONTEMPORARY SPANISH POETRY (3) Various currents in Spanish poetry from the generation of 1927: Lorca, Aleixandre, Salinas, Guillén, Alonso, Alberti, Hernández, Otero and others. *Mr. Brentin*
570. MODERNISMO (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío. *Mr. Moser*
572. SPANISH AMERICAN NOVEL OF THE NINETEENTH AND EARLY TWENTIETH CENTURY (3) Evolution of the genre and representative works. *Messrs. Lyday, Peavler, and Stabb*
573. THE CONTEMPORARY SPANISH AMERICAN NOVEL (3) Evolution of the genre since 1940 and representative novelists. *Messrs. Peavler and Stabb*
575. THE SPANISH AMERICAN ESSAY (3) Tracing the history of ideas in Spanish America through major essayists. *Messrs. Moser and Stabb*
576. TWENTIETH-CENTURY SPANISH AMERICAN POETRY (3) Influential poets and literary movements after *Modernismo*. *Messrs. Lyday and Stabb*
577. SPANISH AMERICAN DRAMA (3) Dramatic literature in Spanish America from colonial times to the present. *Mr. Lyday*
579. COLONIAL LITERATURE (3) Transplantation of European culture to Spanish America, literary genres cultivated in the colonies, and principal writers. *Mr. Moser*
581. THE SPANISH AMERICAN SHORT STORY (3) Critical analysis of the major writers and movements from Echeverría to the present. *Messrs. Lyday, Peavler, and Stabb*
584. SPANISH AMERICAN ROMANTICISM (3) The principal writers and tendencies of the romantic movement in Spanish America. *Mr. Moser*
587. STYLISTIC AND LITERARY CRITICISM (3) Major theories of literary criticism applied to Hispanic literature.
588. SEMINAR IN HISPANIC LITERATURE (3-12) Common and individual research in special problems in Spanish or Spanish American literature.

SPEECH COMMUNICATION (SPCOM)

ROBERT S. BRUBAKER, *Head of the Department*
212 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A.

Graduate Faculty: Senior Members Brubaker, Cohen, Frandsen, Gregg, Holtzman, Nelson, Paulson, Phillips, and White.

Graduate Faculty: Associate Members Barton, Benson, Butt, De Boer, Dunham, Gilbert, Hauser, Johnson, McCormack, Pedersen, Preston, and Wigley.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication, teaching of speech); speech science (voice, diction, phonetics, general semantics); and communicative theory. A thesis is required of all M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies without credit toward the graduate degree. Sp.Com. 400 and 502 are required of all graduate students who do not have their equivalents.

Students with a 3.00 junior-senior average, with scores on the Graduate Record Examination (general), and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPEECH COMMUNICATION (SPCOM)

*115G. ENGLISH AS A SECOND LANGUAGE (3-15) Development of communicative competence using spoken and written English. Intensive (full-time), intermediate, or advanced sections according to diagnostic test results.

- 400. TEACHING OF SPEECH (3) *Messrs. Butt and Pedersen*
- 402. SPEECH AND HUMAN BEHAVIOR (3) *Messrs. Pedersen and Phillips*
- 403. INTERPERSONAL ORAL COMMUNICATION THEORY (3) *Mr. Phillips*
- 410. AMERICAN-ENGLISH PHONETICS (3) *Mr. Brubaker*
- 412. SPEECH CRITICISM (3) *Mr. Arnold*
- 413. (Ling. 413) EXPERIMENTAL LINGUISTICS (3) *Mr. Brubaker*
- 415. RHETORIC OF FILM AND TELEVISION (3)
- 417. DIRECTING FORENSICS (3) *Mrs. Lutz*
- 419. (Journ. 419) COMPARATIVE BROADCASTING SYSTEMS (3) *Mr. Barton*
- 420. SYSTEMS AND THEORIES OF RHETORIC (3) *Mr. Hauser*
- 425. RADIO PROGRAMMING AND PERFORMANCE (3) *Miss Preston*
- 431. ANATOMY AND PHYSIOLOGY OF THE VOCAL MECHANISMS (3) *Mr. Gilbert*
- 435. RADIO AND TELEVISION PROGRAMMING (3) *Mr. Nelson*
- 437. TELEVISION PROGRAMMING AND PERFORMANCE (3)
- 440. SPEECH COMMUNICATION: RESEARCH AND THEORY (3) *Mr. Frandsen*
- 450. DISCUSSION: RESEARCH AND THEORY (2-6) *Ms. Johnson and Mr. Phillips*
- 455. GENDER ROLES IN COMMUNICATION (3)
- 470. NONVERBAL COMMUNICATION (3-6) *Messrs. Benson and Frandsen*
- 475. STUDIES IN MASS PERSUASION IN THE DEMOCRATIC SOCIETY (3) *Mr. McCormack*

*No graduate credit is given for this course.

478. CONTEMPORARY AMERICAN RHETORIC (3) *Mr. Gregg*
480. COMPUTER APPLICATIONS IN SPEECH STUDIES (3)
485. ADVANCED ORAL INTERPRETATION OF LITERATURE (3) *Mr. Wigley*
487. (Journ. 487) MASS COMMUNICATIONS STUDY ABROAD (1-9)
490. PSYCHOLOGY OF SPEAKING AND LISTENING (3) *Mr. Holtzman*
491. COMMUNICATION INTERNSHIP (1-9)
494. TEACHING OF ENGLISH AS A SECOND LANGUAGE (3) *Mr. Holtzman*
495. SPEECH FOR TEACHERS (3) *Mr. Butt*
496. INDEPENDENT STUDIES (1-12)
500. SEMINAR IN AMERICAN ORATORY (2-6) History of American oratory with application of critical standards to the work of specific orators. *Mr. White*
502. RESEARCH METHODS IN SPEECH (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech communication, clinical speech, or theatre arts.
503. SEMINAR IN CRITICISM (3) Study of philosophies and methods available for the critical analysis of rhetorical transactions. Prerequisite: Sp.Com. 412.
505. HISTORICAL DEVELOPMENT OF SPEECH THEORY AND CRITICISM (2-4) Classical theories of speech making from the earliest beginnings to the fall of the Roman Empire. *Mr. Arnold*
506. HISTORICAL DEVELOPMENT OF SPEECH THEORY AND CRITICISM (2-4) Theories of speech making from the Renaissance to the present. *Mr. Arnold*
507. CONTEMPORARY RHETORICAL THEORY (2-4) A study of rhetorical theory from 1930 to the present, focusing on semantic, political, sociological, symbolic, and philosophical perspectives. Prerequisites: Sp.Com. 412, 505 and/or 506. *Messrs. Gregg and Hauser*
508. SEMINAR IN BRITISH ORATORY (2-4) History of British oratory; application of critical standards to the work of selected orators. *Miss Fife*
509. PROBLEMS IN RHETORIC AND ORATORY (2-6) Comparative study of selected orators and rhetoricians. Prerequisite: 6 credits in speech communication.
510. PROBLEMS IN SPEECH EDUCATION (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisites: Sp.Com. 502 and 9 additional credits at the 400 or 500 level in speech communication, clinical speech, or theatre arts. *Mr. Phillips*
520. SEMINAR IN SPEECH SCIENCE (3-6) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech communication, speech pathology and audiology, or psychology. *Messrs. Brubaker and Gilbert*
522. (S.P.A. 522) SPEECH PERCEPTION (3) Transformation of linguistic units into acoustic speech signals, theories of speech perception, and auditory processing of the speech signal. Prerequisites: Sp.Com. 410, 431, 520. *Mr. Gilbert*
530. POLITICAL SPEAKING IN THE BROADCAST MEDIA (3) Study and research of the principles of speaking as they are employed for political purposes when utilizing the broadcast media. *Mr. Nelson*
540. SEMINAR IN PROBLEMS OF TELEVISION AND RADIO (2-4) Study and research in television and radio as they pertain to programming, production, relation to society, and speech. *Mr. Nelson*
550. SEMINAR IN ORAL PERSUASION (2-4) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech communication including Sp.Com. 200. *Messrs. Frandsen and Holtzman*
552. ORAL COMMUNICATION IN INDUSTRY, BUSINESS, AND GOVERNMENT (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communications skills. *Messrs. Barton and Frandsen, Ms. Johnson*
554. SEMINAR IN SMALL GROUP COMMUNICATION (2-4) Communication variables in small groups. Experimental research and innovations in communication in vocational, therapeutic, and educational groups. *Mr. Phillips*

555. **SPEECH COMMUNICATION: PROBLEMS AND PRINCIPLES (2-6)** Prevalent theories of speech influence. *Messrs. Frandsen and Phillips*
575. **RESEARCH PROBLEMS IN SPEECH (1-9)** Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech communication or speech pathology and audiology.
590. **COLLOQUIUM (1-3)**
597. **SPECIAL TOPICS (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

BRUCE M. SIEGENTHALER, *In Charge of Graduate Programs in Speech Pathology and Audiology*
110 Moore Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Frick, Michael, and Siegenthaler.

Graduate Faculty: Associate Members Bienvenue, Chapman, Clouser, Frank, Gilbert, Quick, Volz, and Weiner.

Students may specialize in speech pathology, audiology, or education of the hearing impaired. The programs include the requirement of a number of field trips to diagnostic and treatment facilities and may include a period of internship at an off-campus location to be assigned by the staff. Students should expect to have moderate expenses related to these trips.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages. The nonthesis option is available for the M.S. degree.

Approximately 38 credits are required for admission, distributed among speech pathology, audiology, education of the hearing impaired, speech science, education, and psychology, and including a course in statistics. Students entering without an undergraduate program in the field may be required to take additional make-up work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

430. **INTRODUCTION TO AUDIOLOGY (3)**
433. **VISUAL SPEECH RECEPTION AND AUDITORY TRAINING (3)**
439. **PRACTICUM IN AUDITORY TRAINING AND SPEECH READING (1-5)**
440. **(E.E.C. 440) SURVEY OF SPEECH AND HEARING DISORDERS (3)**
442. **SPEECH PATHOLOGY: ARTICULATION AND STUTTERING (3)**
444. **SPEECH PATHOLOGY: VOICE AND ORGANIC DISORDERS (3)**
445. **PROFESSIONAL PROGRAMS AND RELATIONSHIPS (3)**
449. **PRACTICUM IN SPEECH THERAPY (1-6)**
459. **PRINCIPLES OF CLINICAL MANAGEMENT IN S.P.A. (2)**
460. **COMMUNICATION SKILLS FOR HEARING IMPAIRED I (2)**
461. **COMMUNICATION SKILLS FOR HEARING IMPAIRED II (3)**
462. **CLINICAL BASES OF LANGUAGE DISORDERS (2)**
463. **TEACHING LANGUAGE TO THE HEARING IMPAIRED (3)**
- 464-465. **TEACHING SCHOOL SUBJECTS TO THE DEAF (2 each)**

469. STUDENT TEACHING WITH THE DEAF (3-12)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

515. APPLICATION OF PHYSIOLOGICAL AND ACOUSTICAL CONCEPTS OF SPEECH PATHOLOGY AND AUDIOLOGY (4) Application of practical and theoretical concepts in neurology, physiology, and acoustics to communication disorders with implications for clinical therapy. Prerequisites: 6 credits in speech science and 6 credits in speech pathology and audiology.

516. APPLICATIONS OF PSYCHOLOGY OF SPEECH TO SPEECH PATHOLOGY AND AUDIOLOGY (1) Application of psychological concepts germane to theoretical and practical understanding of communication disorders; implications for clinical speech and language therapy. Prerequisites: 6 credits in speech pathology and audiology and 6 credits in psychology.

517. (Ling. 517) APPLICATIONS OF LINGUISTICS TO COMMUNICATION DISORDERS (1) Application of linguistic theory to the understanding of communication disorders, with clinical implications for speech and language therapy. Prerequisites: 12 credits in speech pathology and audiology, psychology, linguistics, or phonetics.

522. (Sp.Com. 522) SPEECH PERCEPTION (3) Transformation of linguistic units into acoustic speech signals, theories of speech perception, and auditory processing of the speech signal. Prerequisites: Sp.Com. 410, 431, 520.

530. SEMINAR IN AUDIOLOGY (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.

531. SPEECH AUDIOMETRY AND HEARING AIDS (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.

532. ACOUSTICAL INSTRUMENTS FOR HEARING (3) Acoustical instrumentation used for research in hearing, programs of hearing conservation, and noise control, including clinical and industrial applications. Prerequisite: 6 credits in acoustics, audiology, experimental psychology, or speech science at 400 level.

534. NOISE AND HEARING (3) Noise-induced hearing problems; interference with communication; annoyance and community problems caused by acoustic energy; regulations and standards. Prerequisite: 6 credits at the 400 level in acoustics, audiology, experimental psychology, or speech science.

535. PURE TONE AUDIOMETRY (3) Techniques, interpretation, and differential diagnosis of hearing ability by pure tone and related audiometric techniques. Prerequisites: S.P.A. 430, S.P.A. 433, Acs. 401; 6 credits in speech pathology and audiology.

538. PRACTICUM IN AUDIOLOGIC EVALUATION AND SELECTION OF HEARING AIDS (1-5) Prerequisite: S.P.A. 531.

539. ADVANCED PRACTICUM IN EDUCATION OF THE DEAF (1-6) Theoretical and clinical rationale of working with hearing impaired, professional role and relationships, therapy procedures, evaluation of process and outcomes. Prerequisite: S.P.A. 439.

540. ARTICULATION DISABILITIES (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

541. THE VOICE AND ITS DISORDERS (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.

542. STUTTERING (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

543. DIAGNOSTIC PROCEDURES IN CLINICAL SPEECH (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisite: S.P.A. 444.

544. CLEFT PALATE (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.
545. (E.E.C. 545) CEREBRAL PALSY (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multiprofessional habilitative program. Prerequisite: S.P.A. 444.
546. LANGUAGE DISORDERS IN ADULTS (3) Nature, etiology, diagnosis, and management of language disorders in adults. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.
547. (E.E.C. 547) LANGUAGE DISORDERS IN CHILDREN (2) Nature, etiology, diagnosis, and management of language disorders in children. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.
548. PRACTICUM IN SPEECH DIAGNOSIS (1-3) Supervised practice in interviewing, counseling, speech evaluation, and synthesis of psychological, medical, and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.
549. ADVANCED PRACTICUM IN SPEECH THERAPY (1-6) Theoretical and clinical rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.
550. SEMINAR IN SPEECH PATHOLOGY (1-6) Advanced study of special problems and new developments in speech pathology. Prerequisites: S.P.A. 442, 444.
560. RECENT DEVELOPMENTS IN EDUCATION OF THE DEAF (2-6) In-depth seminar-style study of communication disorders associated with deafness, and advanced and experimental attempts at remediation. Prerequisites: 8 credits in education of the deaf or audiology, S.P.A. 430 and 433, and 3 credits in child development or learning theory.
566. EDUCATION AND GUIDANCE OF THE HEARING IMPAIRED (3) Effects of hearing impairment on developmental, educational, social, and vocational adjustment; assisting the hearing impaired toward improved life adjustment. Prerequisites: S.P.A. 430, 433.
567. AUDIOLOGY FOR HEARING AND SPEECH CLINICIANS (3) Etiology, measurement, and differential diagnosis of hearing loss; overview of aural rehabilitation, including hearing aids and auditory training systems. Prerequisites: S.P.A. 430, S.P.A. 433; 6 credits in speech pathology and audiology.
596. INDIVIDUAL STUDIES (1-6)

STATISTICS (STAT)

WILLIAM L. HARKNESS, *Head of the Department*
219 Pond Laboratory

Degrees Conferred: Ph.D., M.S., M.A.

Graduate Faculty: Senior Members Antle, Bartoo, Haight, Harkness, Hettmansperger, Hultquist, and Patil.

Graduate Faculty: Associate Members Arnold, Boswell, Lynch, and Ryan.

Graduate instruction and research opportunities are available in most areas of statistics and probability, including linear models, nonparametric statistics, statistical computing, analysis of count data, multivariate analysis, experimental design, reliability, stochastic processes and probability (applied and theoretical), distribution theory, and statistical ecology.

The opportunity is also available for students to gain practical experience by participating, for academic credit, in the department's consulting and collaborative research program.

For the M.A. degree the candidate must complete 30 course credits, with at least 18 credits (12 in statistics) of 500-level courses; 6 credits of mathematical statistics, Stat. 409 and 410; 3 credits in computer science, Math. 441 or 481; 3 credits in seminars and/or individual studies; and six credits in an approved area. In addition, the M.A. candidate must submit a master's paper. The requirements for the M.S. degree are the same as for the M.A., except that 6 credits of thesis research replace an equal number of course credits, and a thesis is required rather than a master's paper.

The department administers a master's and Ph.D. qualifying examination which all students in the program must take. Students are examined in two areas of their choice from mathematical statistics, applied statistics, and probability. This examination is intended to be taken early in the program and Ph.D. candidacy is contingent on successful completion of the examination.

After admission to candidacy, each Ph.D. candidate is required to pass two comprehensive examinations. One must be in mathematical statistics and the other in an area to be selected by the candidate, subject to the approval of the faculty. There is no foreign language requirement for the Ph.D. in Statistics.

While applications from all students (including those who already have done graduate work) are reviewed, completion of a standard calculus sequence is regarded as a prerequisite. Students with a 3.00 or better junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

The department requires the verbal and quantitative scores on the Graduate Record Examination from those applicants who wish to be considered for financial support. All applicants for admission are encouraged to submit the GRE scores.

Entering graduate students in Statistics for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. The results of this examination must be received by the Department of Statistics at least six months prior to the requested date of admission to the Graduate School.

Students in the Statistics program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

STATISTICS (STAT)

- 401. EXPERIMENTAL METHODS I (3)
- 402. EXPERIMENTAL METHODS II (3)
- 409. (Math. 409) INTRODUCTION TO PROBABILITY THEORY (3)
- 410. (Math. 410) MATHEMATICAL STATISTICS I (3)
- 412. (Math. 412) MATHEMATICAL STATISTICS II (3)
- 418. (A.M. 418, Math. 418) DISCRETE PROBABILITY THEORY (3)
- 427. (Math. 427) DISCRETE STOCHASTIC MODELS (3)
- 451. INTRODUCTION TO APPLIED STATISTICS (3)
- 460. INTERMEDIATE STATISTICAL METHODS (3)
- 461. SAMPLING METHODS (3)
- 462. APPLIED REGRESSION ANALYSIS (3)
- 464. APPLIED NONPARAMETRIC STATISTICS (3)
- 480. INTRODUCTION TO STATISTICAL PROGRAM PACKAGES (1)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 501. DATA ANALYSIS AND REGRESSION (3) Use of simple and multiple regression and correlation to analyze research data; dummy variables, step-wise and non-linear regression. Prerequisite: 6 credits in statistics or Stat. 451; matrix algebra.
- 502. ANALYSIS OF VARIANCE AND DESIGN OF EXPERIMENTS (3) Experimental design and analysis; fixed, mixed, and random effects models; covariance analysis; multiple comparisons; repeated measures; unbalanced data; computer techniques. Prerequisite: 6 credits in statistics.
- 503. ANALYSIS OF EXPERIMENTAL DATA (3) Statistical analysis and interpretation of data. Intended for students who have (or will have) data to analyze. Prerequisites: Stat. 462 or 501; Stat. 502.

504. ANALYSIS OF CATEGORICAL DATA (CONTINGENCY TABLES) (3) Classical analysis of multi-factor contingency tables; linear and log-linear models; measures of association; graphical methods. Prerequisites: 6 credits in statistics, matrix algebra.
505. APPLIED MULTIVARIATE STATISTICAL ANALYSIS (3) Analysis of multivariate data; T^2 -tests; partial correlation; discrimination; MANOVA; cluster analysis; regression; growth curves; factor analysis; principal components; canonical correlations. Prerequisite: 6 credits in statistics.
506. SAMPLING THEORY (3) Theory and application of sampling from finite populations. Prerequisite: 6 credits in statistics.
507. SEQUENTIAL ANALYSIS (3) A thorough discussion of sequential procedures of estimation and testing of hypotheses. Prerequisite: Stat. 410.
509. DISCRETE STATISTICAL MODELS AND METHODS (3) Systematic study of probability models and statistical methods pertaining to statistical analysis of data consisting of single and multiple counts. Prerequisite: Stat. 554.
510. APPLIED TIME SERIES ANALYSIS (3) Identification of models for empirical data collected over time. Use of models in forecasting. Prerequisite: Stat. 462 or 501.
512. (A.M. 512) INTRODUCTION TO STOCHASTIC PROCESSES (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. (Math.) 409 or Stat. (A.M., Math.) 418.
513. (A.M. 513) INTRODUCTION TO STOCHASTIC PROCESSES (3) Markov chains, random walks and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. (A.M.) 512.
- 517-518. (Math. 517-518) PROBABILITY THEORY (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.
524. ECOMETRICS (3) Stochastic models and statistical methods in ecological problems; population dynamics, spatial patterns in populations of one, two, or more species. Prerequisite: Stat. 409 or 418.
528. QUEUING MODELS IN TRANSPORTATION (3) Arrival patterns, the service mechanism, queue discipline, delays, multiple queues, problems involving interrupted flow, multiframe routes.
534. (M.E.R. 534) DYNAMIC PROGRAMMING (3) The study of the concepts underlying model-building and optimization of dynamic systems; applications to engineering, economic and environmental systems. Prerequisites: Stat. 418; I.E. 405 or Q.B.A. 451.
542. (Math. 542) STATISTICAL DISTRIBUTION THEORY IN SCIENTIFIC WORK: I. DISCRETE MODELS (3) Statistical distributions arising in scientific modeling and statistical inference; structures, interrelations, characterizations, and simulation with practical examples. Prerequisite: Stat. (Math.) 410; knowledge of matrix algebra.
543. (Math. 543) STATISTICAL DISTRIBUTION THEORY IN SCIENTIFIC WORK: II. CONTINUOUS MODELS (3) Statistical distributions arising in scientific modeling and statistical inference; structures, interrelations, characterizations, and simulation with practical examples. Prerequisite: Stat. (Math.) 542.
551. LINEAR MODELS I (3) Statistical distribution theory of quadratic forms and linear transformations; full-rank estimation; regression; response surfaces; Cochran's theorem. Prerequisites: Stat. 502; Math. 441 or 481.
552. LINEAR MODELS II (3) Non-full-rank statistical inference, interaction, variance components, covariance analysis, cross, hierarchical and incomplete classification theory and methodology. Prerequisite: Stat. 551.
558. THEORY OF STOCHASTIC PROCESSES (3) Stationary, independent, and orthogonal processes, discrete and continuous Markov processes, martingales and semi-martingales applications. Prerequisite: Stat. (Math.) 518.
559. (Math. 559) THEORY OF STOCHASTIC PROCESSES (3) Stationary, independent, and orthogonal

processes, discrete and continuous Markov processes, martingales and semi-martingales applications. Prerequisite: Stat. (Math.) 518.

561. STATISTICAL INFERENCE I (3) Multiparameter estimation; linear estimation; maximum likelihood estimation; Bayesian estimation; large sample properties and procedures. Prerequisite: Stat. 410.

562. STATISTICAL INFERENCE II (3) Testing statistical composite hypotheses; invariance principles; Bayesian statistics; large sample properties and procedures. Prerequisite: Stat. 561.

564. NONPARAMETRIC STATISTICS: THEORY (3) Estimation and testing based on nonparametric procedures for location and regression models. Distribution theory and asymptotic efficiency. Prerequisites: Stat. 410 and 3 additional credits in statistics.

565. THEORY OF MULTIVARIATE STATISTICAL ANALYSIS (3) Multivariate normal, Wishart and related distribution; Hotelling's T^2 and Cochran's theorem; classification; growth curves; cluster analysis; factor analysis. Prerequisite or concurrent: Stat. 505. Prerequisites: Stat. 410; Math. 441 or 481.

572. STATISTICAL DECISION THEORY I (3) Structure of statistical games; optimal strategies, fixed sample-size games. Prerequisite: Stat. 410.

590. COLLOQUIUM (1-3)

591. SEMINAR IN PROBABILITY THEORY (1-6) Lectures on current and recent research in various special topics in probability theory.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

TEACHING AND CURRICULUM (T & C)

ROBERT LESNIAK, *In Charge of the Graduate Program in Teaching and Curriculum*
The Capitol Campus, Middletown, PA 17057

Degree Conferred: M.Ed.

Graduate Faculty: Senior Member Lear.

Graduate Faculty: Associate Members Alexander, Allison, Ammon, Barnes, Eisenstein, Grella, Haber, Lesniak, Miller, Smith, Susskind, Swetz, and Towns.

The Master of Education in Teaching and Curriculum at Capitol Campus provides to full-time and part-time students a curriculum designed to develop master teachers for public and private school instruction and to develop education specialists (teaching certification not required) for the areas of business, industry, government, medicine, and other social services. In addition, specialties are available in particular areas, such as: reading, urban education curriculum, early childhood education, elementary education and secondary English, social studies, and mathematics education.

Specifically, the goals of the program are to develop in students (1) the ability to communicate effectively either with school-aged students and their parents or with co-workers and/or clients; (2) the ability to conduct an instructional program which provides a sound intellectual and emotional climate for learning; (3) competence in a variety of teaching methods and in the utilization of materials and content appropriate for an effective instructional program; (4) the ability to interpret and to evaluate educational literature and research; and (5) the ability to describe and to evaluate major issues and current trends in instructional curriculum practice and development.

Certification programs are also available in the areas of Reading Specialist (K-12) and Private Nursery School Teachers. For graduates of education undergraduate programs, a total of 36 credits of work normally will be required. Graduates of other undergraduate programs normally will be expected to complete substantially more work to satisfy the requirements for this degree. Some of this additional

work may include undergraduate courses. Program requirements include 3 credits in foundations of education; each student will be expected to complete from one-third to two-thirds of the work in courses other than education courses; and a minimum of 12 credits in 500-level courses must be completed. The last 12 credits in a student's program must be earned at the Capitol Campus. The application and transcript should be sent directly to the Graduate Office, The Capitol Campus, Middletown, PA 17057.

THEATRE ARTS (THEA)

DOUGLAS N. COOK, *Head of the Department of Theatre and Film*
103 Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Members L. Manfull and Walters.

Graduate Faculty: Associate Members Allison, Bouwman, Cook, Crocken, Duque, Firmin, Maddox, H. Manfull, Sabatine, and A. Smith.

This program emphasizes the study of the theatre with the following major objectives: (1) to help each graduate student attain skills and proficiencies in theatre arts; (2) to provide the training, discipline, and opportunities essential to the development of a professional ability in at least one area of the arts of the theatre; (3) to prepare students for active careers in academic, professional, and/or community theatre in a recognizably competitive job market; and (4) to assist students in acquiring discriminating taste and critical judgment in drama and theatre.

The Master of Arts degree program provides advanced training in the broad field of the theatre arts. It is designed to prepare the candidate for: (1) professional employment as a Theatre Arts teacher on the secondary or junior college level; (2) critical study and research particularly in preparation for the pursuit of a related doctorate or professional degree; and (3) related professional work in industry, business, or the arts. Two areas of study are required: general theatre (history, theory, criticism, dramatic literature, and research) and practical theatre (acting, directing, design, and technical theatre).

Requirements for admission to the M.A. program are:

1. A broad undergraduate preparation in theatre, including three credits each in acting, directing, stagecraft, and theatre history; and six credits of dramatic literature.
2. An undergraduate grade-point average of no less than 2.50 on a 4.00 scale.
3. Twelve credits in related subject areas such as oral interpretation, art, and music.
4. A vita and at least three letters of recommendation should be submitted.

The M.F.A. program is planned to provide a professional emphasis. Specialization in the following areas is stressed: performance (acting or directing); production (scene design, costuming, lighting, or technical direction); or playwriting. A required final project in the area of specialization includes a monograph. The program requires approximately nine terms to complete.

Requirements for admission to the M.F.A. program are:

1. Twenty-four credits in theatre arts, including one course each in acting, directing, and theatre crafts. Related courses in the student's area of specialization may be accepted.
2. All students are to submit evidence of ability in their areas of specialization under arrangements to be made with the department. Auditions, prompt books, portfolios, manuscripts, and other appropriate presentations are to be submitted by applicants to the various study programs.
3. A vita and letters of recommendation (at least three) are to be submitted.
4. Personal interviews should be arranged by all students.

All students in the M.A. and M.F.A. programs who are deficient in the required undergraduate courses may be requested to take additional course work in the areas of deficiency without degree credit.

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

All graduate majors are required to participate in University Theatre productions in positions of responsibility.

Theatre facilities are: the Playhouse, a proscenium-thrust theatre; the Pavilion, an arena or three-quarter theatre; theatre production studios for scenic, property, and costume preparation; rehearsal and dance studios; and a film laboratory with screening and editing facilities. Other University performance facilities include Schwab Auditorium, Kern Assembly Room, Music Concert Hall, and the Milton S. Eisenhower Auditorium with a seating capacity of 2,600. On the campus are several FM radio stations and WPSX, the University's educational TV station.

Related courses offered by other departments may be taken. Dramatic literature courses are available: Class. 411; C.Lit. 486, 487, 588; Engl. 438, 444, 445, 478, 488, 548, 549; Fr. 446, 461, 518, 534, 535, 567; Greek 421, 422. Design and technical courses are available in the Departments of Art, Art History, Engineering, Art Education, Architecture, Human Development, and Vocational Industrial Education. Courses in performance areas are available in the Departments of Music, Music Education, Physical Education, and Speech Communication.

THEATRE ARTS (THEA)

400. ADVANCED THEATRE AND FILM PROJECTS (1-6)
401. HISTORY OF ANCIENT AND MEDIEVAL THEATRE (3)
402. HISTORY OF RENAISSANCE AND ORIENTAL THEATRE (3)
403. HISTORY OF MODERN EUROPEAN AND BRITISH THEATRE (3)
405. HISTORY OF AMERICAN THEATRE (3)
409. FUNDAMENTALS OF CREATIVE PERFORMANCE FOR CLASSROOM TEACHERS (3)
410. CREATIVE DRAMATICS WITH CHILDREN (3)
411. PROJECTS IN CREATIVE DRAMATICS (2)
415. CHILDREN'S THEATRE ENSEMBLE (3 per term, maximum of 9)
416. STAGING THEATRE WITH CHILDREN (3)
417. EXPERIMENTAL TECHNIQUES IN CHILDREN'S THEATRE (3)
418. PUPPETRY (3)
420. ADVANCED VOICE AND DICTION FOR THE ACTOR (3 per term, maximum of 6)
421. DIALECTS FOR THE ACTOR (3 per term, maximum of 6)
422. PERFORMANCE FOR THE CAMERA (3)
423. TECHNIQUES AND STYLES OF THEATRE JAZZ DANCE (3 per term, maximum of 6)
424. DANCE FOR THE THEATRE (3)
425. DANCE FOR THE CONTEMPORARY MUSICAL THEATRE (2-6)
426. CHOREOGRAPHY FOR THE THEATRE (3 per term, maximum of 9)
427. THEATRE MAKEUP (2)
428. ADVANCED ACTING PROJECTS (1-9 per term, maximum of 9)
429. THEATRE PERFORMANCE PRACTICUM (1-6)
434. DIRECTING (3)
435. REHEARSAL METHODS FOR THE DIRECTOR (3)
436. CENTRAL STAGING (3)
437. DIRECTING FOR FILM AND TELEVISION (3)
445. ADVANCED PLAYWRITING (3-6)
446. ADVANCED SCREENWRITING (3-6)
450. ADVANCED SCENE DESIGN (3-6)
460. COSTUME DESIGN (3)
461. COSTUME CONSTRUCTION (3)
462. DRAFTING HISTORICAL COSTUMES FOR THE STAGE (3)
474. STAGE LIGHTING (3)
479. STAGE AND PRODUCTION MANAGEMENT (3)
485. SOUND FOR THEATRE PRODUCTION (3)
489. THEATRE PRODUCTION PRACTICUM (1-6 per term, maximum of 12)
490. MOTION PICTURE TECHNIQUES (3-6)
491. FILM AUTHORS I (3)
492. FILM AUTHORS II (3)
493. FILM AUTHORS III (3)

494. DOCUMENTARY IN FILM AND TELEVISION (3)
499. ADVANCED FILM PRODUCTION PRACTICUM (1-12 per term, maximum of 12)
500. THEATRE RESEARCH: SOURCES AND PROCEDURE (3) Source materials and techniques as applied to theatre research; the form and content of theses and monographs.
503. THEATRE CRITICISM AND THEORY (3)
505. THEATRE HISTORY (3) Specific aspects of theatre from ancient times to the present.
522. ACTING I (4) Interpretation of theatrical styles: the tradition of tragedy; voice and movement.
523. ACTING II (4) Interpretation of theatrical styles: the tradition of comedy; voice and movement. Prerequisite: Thea. 522.
524. ACTING III (4) Interpretation of theatrical styles: forms of modern realism; voice and movement. Prerequisite: Thea. 523.
525. ACTING AND DIRECTING THEORY (3) The actor and director as related to cultural environment from the Greek theatre through the post-Stanislavskian theorists.
528. ADVANCED ACTING PROJECTS (3-9) Advanced performance projects for the second- and third-year M.F.A. actor who has completed all other performance courses.
530. PLAY INTERPRETATION FOR THE DIRECTOR (3) Theory and practice in the analysis and implementation of story, style, and form.
531. SPECIAL FORMS IN DIRECTING (3) Applied theory and techniques for various genres and periods of drama. Prerequisite: Thea. 530.
533. PROJECTS IN DIRECTING (1-6 per term)
535. EXPERIMENTAL THEATRE (1-3) Operational research and experimental methods in the preparation, planning, execution, observation, and evaluation of production.
540. PLAYWRITING (3-6) Focus on problems in writing the full-length script through seminar, play reading, and individual session.
543. PROJECTS IN PLAYWRITING (1-9) Preparation of the script for revision during and rewriting following production of the student's original play. Prerequisite: production approval.
553. DESIGN AND TECHNICAL PRODUCTION (1-6 per term) Special projects in design and technical execution of scenery, costumes, lighting, sound, and special effects.
560. COSTUME DESIGN (1-6) Design concepts, rendering, and execution of costumes for the stage.
574. LIGHTING FOR THEATRE PRODUCTION (3) Design techniques for production in arena, thrust, and proscenium theatre situations.
580. THEATRE TECHNOLOGY (3) Design consultation and specification of equipment, systems, and movable structures for new theatres; structures and projection devices for production.
582. THEATRE ADMINISTRATION (3) The theatre: organization and management.
583. PROJECTS IN THEATRE ADMINISTRATION, MANAGEMENT, AND OPERATIONS (1-6)
585. THEATRE PLANNING (3) Processes and problems in planning and designing theatres: performance, audience, and technical requirements.
590. COLLOQUIUM (1-3)
591. SPECIAL PROBLEMS IN FILM AND TV (1-3 per term)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

URBAN AND REGIONAL PLANNING (UR PL)

ROBERT A. SIMKO, *Head of the Program*
The Capitol Campus, Middletown, PA 17057

Degree Conferred: M.R.P.

Graduate Faculty: Senior Members Ferguson, Hand, and McDermott.

Graduate Faculty: Associate Members Buskirk and Simko.

The objective of this interdisciplinary program is to train professional planners who will be aware of the needs of citizens so that they can develop programs for sound social, political, economic, and cultural advancement through the enlightened management of all resources. The nonthesis option is available for this program.

For admission a student should have had at least one course each in economics, sociology or political science, geography or geology, graphics, and statistics. Students may be admitted with limited deficiencies but are required to remove the deficiencies early in the program without graduate degree credit. Applicants should submit scores on the Graduate Record Examination with their application. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered up to the number of spaces available. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

REGIONAL PLANNING (R PL)

400-401. PRINCIPLES OF REGIONAL PLANNING (3-6)

410. PLANNING PROGRAMS (3)

440. PROBLEMS IN COMMUNITY AND REGIONAL PLANNING (1-9)

501. APPLIED METHODOLOGIES IN REGIONAL PLANNING (3) Selected methodologies used in planning, including: demographic projections, simulations, network analyses, threshold analyses, allocation and location models. Prerequisite: R.Pl. 500.

502. REGIONAL SYSTEMS ANALYSIS (3-6) Spatial structure of regional and interregional systems. Theories of regional development. Spatial measures of location, density, central tendency and dispersion.

510. PLANNING TECHNIQUES AND ANALYSIS I (3) Regional socioeconomic structure, problems, and factors in planning; data collection, analysis, and implications.

520. PLANNING TECHNIQUES AND ANALYSIS II (3) Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.

530. PLANNING TECHNIQUES AND ANALYSIS III (3) Effects of political, cultural, and physical factors on planning.

540. PROBLEMS IN REGIONAL PLANNING (1-9) Planned individual projects involving library, laboratory (studio); or field work.

587. MASTER'S PROJECT (1-6) An original scholarly master's project initiated by the student, supervised by an appropriate professor, and judged by a committee.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

VETERINARY SCIENCE (V SC)

ALFRED L. BORTREE, *Head of the Department*
115D Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bortree, Eberhart, Gentry, Glantz, Rothenbacher, Scholz, and Zarkower.

Graduate Faculty: Associate Members Ferguson, Patton, and Swope.

Areas of specialization include veterinary pathology, veterinary physiology, veterinary microbiology, and immunology. There is opportunity for cooperative research with other departments in animal science, microbiology, and physiology. Unless excused by specific departmental action, all doctoral candidates must attain the master's degree as a step toward candidacy for the Ph.D. degree. A thesis is required of all candidates for the M.S. degree.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by proficiency in reading one foreign language. In the case of foreign students whose native language is other than English, this requirement may be waived with the approval of the doctoral committee.

Prerequisite for admission is a veterinary degree or a bachelor's degree in a related biological field. Adequate preparation in the basic sciences compatible with the candidate's objectives is required. Students may be admitted with limited deficiencies but are required to remove undergraduate deficiencies without degree credit.

The best-qualified applicants with a 3.00 junior-senior average and appropriate course backgrounds will be accepted to fill available spaces for new students. Students with a 2.50 junior-senior average and special backgrounds, abilities, and interests may be considered. Academic records of candidates with a doctor of veterinary medicine degree or the M.S. degree will be reviewed and acted on by the graduate faculty of the department.

VETERINARY SCIENCE (V SC)

- 401. ECOLOGY OF ANIMAL DISEASE (3)
- 405. LABORATORY ANIMAL SCIENCE (3) *Mr. Ferguson*
- 407. DAIRY HERD HEALTH PROGRAMS (2)
- 418. METHODS OF ANIMAL CELL CULTURE (3) *Mr. Patton*
- 420. GENERAL ANIMAL PATHOLOGY (3) *Mr. Rothenbacher*
- 496. INDEPENDENT STUDIES (1-12)

- 525. MECHANISMS OF HYPERSENSITIVITY AND IMMUNOPATHOLOGY (3) Concepts of hypersensitivity and special consideration of immunopathological conditions. Prerequisites: Biol. 437, Microb. 410, and 3 credits of pathology. *Mr. Zarkower*
- 528. DIAGNOSTIC PATHOLOGY (3-9) Gross examination of animals and birds, their tissues and body fluids for pathologic changes. Prerequisites: 6 credits in pathology, microbiology, or infectious diseases.
- 535. ACQUIRED AND CONGENITAL DISORDERS OF METABOLISM (3) Abnormalities and alterations in metabolism due to dysfunctions of animal organs. Prerequisites: 6 credits in general biochemistry and 3 credits in animal physiology. *Mr. Scholz*
- 550. EXPERIMENTAL ANIMAL SURGERY (3) Principles of surgical preparation of experimental animal models for biological research, including aseptic procedures, anesthesia, surgical techniques, and aftercare. Prerequisites: Biol. 42, 421; V.Sc. 405. *Mr. Kavanaugh*
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

VOCATIONAL EDUCATION (VOCED)

TWYLA SHEAR, *In Charge of Graduate Programs in Vocational Education*
212 Rackley Building

Degrees Conferred: Ph.D., D.Ed.

Graduate Faculty: Senior Members Brantner, Curtis, East, Long, Love, Ray, Shear, Stinson, and Welch.

Graduate Faculty: Associate Members Anthony, Detwiler, Mortensen, Murray, Thal, Weis, and Williams.

This intercollege program emphasizes administration, research, teacher education and supervision, and curriculum development and design across program areas in vocational education.

A minimum of 45 credits is required in the major, to be divided among vocational education, general professional education, and social and behavioral science courses. A minor program of study is required for the D.Ed. degree and is optional for the Ph.D. degree, and may be developed within one of five social and behavioral science options, in general studies, or in other areas approved by the candidate's committee.

The communication and foreign language requirement for the Ph.D. degree may be satisfied from nine options, which include foreign languages, computer science, statistics, technical writing, and philosophic thought.

For admission, students must have a master's degree. Either the master's degree or the bachelor's degree must be in a vocational education specialization, or the applicant must have professional experience in vocational education.

Courses appropriate to these degrees taught in the three participating departments are: Ag.Ed. 418v, 420v, 422v, 424v, 426v, 434v, 501v, 502v, 508v, 509v, 520v, 521v, 524v, 530, 590v, 596v; I.Ed. 402v, 403v, 408v, 409v, 412v, 415v, 420v, 427v, 446v, 450v, 501v, 506v, 510v, 550v, 556v, 557v, 558v, 559v, 560v; H.E.Ed. 406v, 410v, 477v, 478v, 479v, 480v, 481v, 482v, 503v, 504v, 510v, 511v, 518v, 521v, 530v, 577v.

VOCATIONAL EDUCATION (VO ED)

500v. PHILOSOPHY OF VOCATIONAL EDUCATION (3) Influence of legislative, economic, and social-psychological developments on the status and role of public vocational education in the United States.

508v. ADMINISTRATION OF VOCATIONAL EDUCATION (3) Concepts, strategies in administration of vocational programs in comprehensive high schools, area vocational technical schools, proprietary schools, and colleges.

530v. INTERNSHIP (1-10) Internship at cooperating school, governmental agency, or research institution, under supervision of graduate faculty. Prerequisites: admission to candidacy and completion of 15 credits in residence beyond master's degree.

590v. COLLOQUIUM (1-3)

596v. INDIVIDUAL STUDIES (1-6)

597v. SPECIAL TOPICS (1-6)

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

FREDERICK G. WELCH, *In Charge of Graduate Programs in Vocational Industrial Education*
119 Rackley Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Andreyka, Brantner, Long, and Welch.

Graduate Faculty: Associate Members Detwiler, Phelps, Wahl, and Wircenski.

Emphasis may be placed upon preparation for teaching, supervision, administration, research, or teacher education. The primary focus of the program is preparation for entry into responsible positions within the broadly conceived field of vocational industrial education.

The communication and foreign language requirement for the Ph.D. degree may be met by the successful completion of selected courses in statistics and computer programming.

Persons admitted must have successfully completed a B.S. degree with a 2.50 grade-point average in vocational industrial education or fields related to vocational, safety, or technical education, or health occupations. Two years or more of experience in vocational industrial education, industrial training, military technical training, or work experience in an occupation related to vocational industrial education, vocational education, health occupations, safety education, or technical education are also required for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

INDUSTRIAL EDUCATION (I ED)

402v. SUPERVISION OF VOCATIONAL EDUCATION (3)

403v. SUPERVISED FIELD WORK (6)

408v. OCCUPATIONS (3)

409v. TESTS AND MEASUREMENTS (3)

415v. PROBLEMS IN COORDINATING VOCATIONAL EDUCATION (3)

427v. ADVANCED COURSE OF STUDY BUILDING (3)

446v. IMPROVEMENT OF INSTRUCTION IN VOCATIONAL EDUCATION (4)

450v. SHOP LAYOUT AND MANAGEMENT (3)

496v. INDEPENDENT STUDIES (1-12)

497v. SPECIAL TOPICS (1-6)

501v. SEMINAR IN VOCATIONAL EDUCATION (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. ADMINISTRATION OF VOCATIONAL EDUCATION (3) The job of the local director of industrial education in organizing and developing city and other local programs of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. VOCATIONAL EDUCATION FOR ADMINISTRATORS (3) Designed for school administrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. 1v or trade or teaching experience.

550v. RESEARCH IN VOCATIONAL EDUCATION (3) Research techniques in vocational industrial education.

556v. FEDERAL LEGISLATION (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

557v. PRESENT-DAY LOCAL, PERSONNEL, AND CURRICULUM PROBLEMS (2-3) Various plans, techniques, and practices.

WILDLIFE MANAGEMENT

558v. STATE AND LOCAL SUPERVISION AND ADMINISTRATION (2-3) The more important recent problems in organization, supervision, and administration.

559v. VOCATIONAL TECHNICAL EDUCATION (2-3) Problems of organization and administration of programs of technical education at the secondary and post-secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. PHILOSOPHY OF INDUSTRIAL EDUCATION (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

596v. INDIVIDUAL STUDIES (1-6)

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

WILDLIFE MANAGEMENT (W L M)

ROBERT S. BOND, *Director of the School of Forest Resources*
101 Ferguson Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members George, Hutnik, Lindzey, and Ward.

Graduate Faculty: Associate Members Kelly, Rader, Storm, and Wakeley.

Programs are designed to give students an understanding of the biology and management of wildlife species and their environments, and include training in: wildlife ecology, nutrition, physiology, behavior, and pathology of a wildlife species or species groups; study of successional stages, land use, and management of various habitats and their impact on wildlife populations; population dynamics and manipulation of animal numbers; and studies of recreational, aesthetic, and socioeconomic values of wildlife. Most programs of study are strengthened by including appropriate courses offered by related departments. A thesis is required. The Ph.D. degree in forest resources allows specialization in wildlife ecology and management at the doctoral level (see Forest Resources).

For admission, an applicant should have at least a 2.75 grade-point average, a 3.00 junior-senior average, and should have courses that are basic to the individual's field of specialization. Ordinarily these include 12 credits in communication, 12 credits in social sciences and humanities, 12 credits in quantification including calculus and statistics, 9 credits in physical sciences, 9 credits in biological sciences, and 18 credits in forest products, forestry, wildlife, or related courses. Graduate Record Examination scores and three reference reports (forms supplied on request) and a brief statement describing the applicant's academic goals, career interests, and special qualifications are required. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to admission requirements may be made for students with special backgrounds, abilities, and interests.

WILDLIFE (WILD)

408. MAMMALOGY (3)

427. RANGE ECOLOGY AND MANAGEMENT (3)

430. WILDLIFE ECOSYSTEMS (3)

446. WILDLIFE ECOLOGY (3)

447. WILDLIFE MANAGEMENT (3)

492. FIELD RESEARCH TECHNIQUES (3)

493. LABORATORY TECHNIQUES IN WILDLIFE RESEARCH (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

547. WILDLIFE MANAGEMENT (3) Management, maintenance, and manipulation of wildlife populations and habitat. Prerequisite: Wildl. 447.

551. WILDLIFE BIOMETRICS AND POPULATION ANALYSIS (3) Application of biometrics and mathematics to concepts and problems in wildlife ecology with emphasis on population analysis. Prerequisites: 3 credits in animal ecology and 6 credits in biometrics or statistics.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2)

ZOOLOGY (ZOO)

E. S. LINDSTROM, *Head of the Department of Biology*
208 Erwin W. Mueller

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cooper, Dunson, Hibbard, Hollis, MacCluer, Wickersham, and Williams.

Graduate Faculty: Associate Members Arnold, Beatty, Dachtler, Mitchell, Neff, Pearson, Reimer, Rheuben, and Turpen.

This program offers emphasis in animal behavior, cell biology, developmental biology, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, morphology, physiology, or population dynamics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Admission is restricted to students who have a baccalaureate degree in a biological science with emphasis on zoological subjects and adequate preparation in mathematics and the physical sciences. A cumulative undergraduate average of at least 3.00 is required. Each applicant must provide scores from the Graduate Record Examination, letters from two persons who are familiar with the student's academic competence, and a personal statement of interests and objectives.

NOTE: *For courses in Zoology and related subjects see Biology, Genetics, and Physiology.*

OTHER GRADUATE COURSES

The following courses are in fields in which neither graduate major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department head or program chairman, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400-series courses in degree programs apply to these courses.

AGRICULTURE, GENERAL (AG)

- 400. INTRODUCTORY BIOMETRY (3)
- 430. INTERNSHIP (1-10)

AMERICAN STUDIES (AM ST)

- 402. SEMINAR IN AMERICAN STUDIES (3-9)
- 405. ETHNICITY AND THE AMERICAN EXPERIENCE (3)
- 501. THEORY AND METHODS OF AMERICAN STUDIES (3) Theory and methods for the analysis of American culture: history of ideas, analysis of myth and symbol, comparative arts, etc.
- 502. PROBLEMS IN AMERICAN STUDIES (3-6) A variable-content course, addressed each term to a specific problem, topic, or period in American culture.

ANIMAL SCIENCE (AN SC)

- 422. QUANTITATIVE INHERITANCE AND ANIMAL BREEDING (3)
- 455. ANIMAL GENETICS (2)

APPLIED MATHEMATICS (A M)

- 405. (Math. 405) FOURIER SERIES AND PARTIAL DIFFERENTIAL EQUATIONS (3)
- 417. (Math. 417) TENSOR ANALYSIS (3)
- 418. (Math. 418, Stat. 418) DISCRETE PROBABILITY THEORY (3)
- 419. (Phys. 419) THEORETICAL MECHANICS (3)
- 431. (Math. 431) ORDINARY DIFFERENTIAL EQUATIONS (3)
- 441. (Math. 441) MATRIX ALGEBRA (3)
- 451. FUNCTIONS OF SEVERAL VARIABLES (3)
- 452. (Math. 452) FUNCTIONS OF A COMPLEX VARIABLE (3)
- 461. (Phys. 461) THEORETICAL MECHANICS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 510-511. LINEAR METHODS (3 each) Matrices, quadratic forms, ordinary and partial differential equations, integral equations, transforms, Fourier series. Prerequisite or concurrent: A.M. (Math.) 452.
- 512. (Stat. 512) INTRODUCTION TO STOCHASTIC PROCESSES (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. 409 or A.M. (Stat., Math.) 418.
- 513. (Stat. 513) INTRODUCTION TO STOCHASTIC PROCESSES (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: A.M. (Stat.) 512.
- 573. SPECIAL TOPICS (2-12) Various topics according to instructor and students. Prerequisite: second-year graduate standing.

THE ARTS (ARTS)

- 400. CONTEMPORARY FORMS IN THE ARTS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

BEHAVIORAL SCIENCE (BEHSC)

- 410. BIOSTATISTICS (2)
- 501. BEHAVIORAL SCIENCE (3) Integration of biopsychosocial substrates of behavior, variability in behavior, growth and development, and behavioral correlates of disease and health.
- 502. BEHAVIORAL SCIENCE (2) Continued integration of biopsychosocial substrates with emphasis on adaptation, growth and development, and behavioral correlates of disease and health.
- 503. HEALTH BEHAVIOR AND HUMAN ECOLOGY (3) Behavioral substrates with emphasis on health behavior, human ecology, stress, behavioral factors in disease, society, prevention, and health systems. Prerequisite: Beh.Sc. 502.
- 511. MEDICAL STATISTICS AND RESEARCH DESIGN (2) Use of theoretical and applied statistics in medical research design and in the interpretation of data.
- 531. BEHAVIORAL AND PHYSIOLOGICAL CORRELATES OF STRESS (3) Effects of stress on all physiological processes; role of learning, cognition, personality, and culture in adapting to stress.
- 533. BIOFEEDBACK AND THE CONTROL OF INTERNAL RESPONSES (2) Discusses theoretical and clinical applications of voluntary control over EEG, cardiovascular and muscle activity, body temperature, and other physiological processes.
- 535. NERVOUS SYSTEMS AND BEHAVIOR (3) Synthesis on behavioral science, neurobiology, and physiology with emphasis on integrative functions of peripheral, central, and autonomic nervous systems.
- 537. MECHANISMS OF MEMORY (2) Discussion of physiological mechanisms involved in information storage and retrieval. Experimental design in memory research is emphasized.
- 551. HEALTH, ILLNESS, AND CULTURE (3) A medical sociology seminar devoted to the socio-cultural aspects of health and sickness.
- 555. BEHAVIOR CHANGE (3) Review of behavioral science research and theory relevant for behavior change procedures used in medicine.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

BIOLOGICAL HEALTH (B H)

- 401. BEHAVIORAL CONCEPTS AND HEALTH INTERVENTION (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

BLACK STUDIES

Students who wish to take courses in black studies may select from the following: Anthy. 424, 447; Com.D. 407, 419; C.Lit. 422, 423; C.F.Ed. 466; Econ. 424, 461; Fr. 458; Geog. 444; Hist. 459, 477, 478; Pl.Sc. 453, 454; Soc. 415, 419.

BUSINESS EDUCATION (BUSED)

575. ADMINISTRATION AND SUPERVISION IN BUSINESS EDUCATION (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

576. INTRODUCTION TO RESEARCH IN BUSINESS EDUCATION (3) Methods of research in business education; opportunity to compile annotated bibliographies on current problems; analysis and evaluation of significant research.

577. EVALUATION OF RESEARCH AND EMPIRICAL LITERATURE IN BUSINESS EDUCATION (3) Application of evaluation methods to current literature in business education; special attention to research studies. Prerequisite: Bus.Ed. 576.

578. SEMINAR IN BUSINESS EDUCATION (1-6) Intended for graduate students preparing theses or final documents, or for those working on special studies in business education. Prerequisite: Bus.Ed. 577.

CHINESE (CHNS)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

COMMUNITY DEVELOPMENT (COM D)

402. POLITICS, POLICY, AND COMMUNITY ACTION (3)

404. INTERPERSONAL AND GROUP PROCESSES IN COMMUNITY CHANGE (3)

405. COMMUNITY MENTAL HEALTH: AN ECOLOGICAL APPROACH TO HUMAN SERVICES (3)

407. COMMUNITY CONFLICT THEORY (3)

417. IDENTIFYING COMMUNITY POWER STRUCTURES (3)

419. COMPARATIVE COMMUNITY DEVELOPMENT (3)

421. AGING AND SOCIAL POLICY (3)

433. PLANNING OF COMMUNITY SERVICE PROGRAMS (3)

434. EVALUATION OF COMMUNITY SERVICE PROGRAMS (3)

435. COST-EFFECTIVENESS ASSESSMENT OF COMMUNITY SERVICE PROGRAMS (3)

450. COMMUNITY SERVICES STUDIO (1-6)

490. ADVANCED FIELD WORK (4)

491. FIELD WORK IN COMMUNITY DEVELOPMENT (2)

492. RESEARCH IN FIELD WORK (4)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

CONSUMER STUDIES (C S)

416. (I.F.S. 416) CONSUMER ROLE OF FAMILY (3)

420. CONSUMER INDUSTRIES (4)

430. SOCIETAL ASPECTS OF CONSUMER PROBLEMS (2)

CULTURAL FOUNDATIONS OF EDUCATION (CF ED)

415. (Anth. 415) ANTHROPOLOGY OF EDUCATION (3)

416. (Soc. 416) SOCIOLOGY OF EDUCATION (3)

417. PHILOSOPHIC BASIS OF EDUCATION (3)

418. HISTORY OF EDUCATION IN THE UNITED STATES (2-3)

419. HISTORY OF EDUCATION IN ANCIENT AND MEDIEVAL TIMES (3)

420. HISTORY OF MODERN EUROPEAN EDUCATION (3)

422. INTRODUCTION TO COMPARATIVE EDUCATION (3)

425. EDUCATION IN AFRICA (3)

466. RACE, POVERTY, AND THE SCHOOLS (3)

515. **EXPERIMENTALIST PHILOSOPHIES OF EDUCATION (2-3)** John Dewey's educational philosophy and later formulations by Bode, Kilpatrick, Childs, Brameld, and others. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

516. **TOPICAL SEMINAR ON SCHOOL AND SOCIETY (2-6)** An intensive and comprehensive analysis of one selected aspect of the relationship of educational institutions to their societal setting. Prerequisite: C.F.Ed. 416.

517. **EXISTENTIAL PHILOSOPHY OF EDUCATION (3)** The nature, aim, organization, policy, and process of education examined from the viewpoint of existential philosophy and existential phenomenology. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy at the 400 level or above.

519. **CONTEMPORARY PHILOSOPHIES OF EDUCATION (2-3)** Implications for education of various types of realism, idealism, existentialism, and analytic philosophy. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

521. **EDUCATION IN THE LATIN-AMERICAN COUNTRIES (2-3)** Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina. Prerequisite: C.F.Ed. 422 or 6 credits in Latin-American studies.

522. **COMPARATIVE EUROPEAN EDUCATION (2-3)** Educational policies and practices in school systems in western and central European nations. Prerequisite: C.F.Ed. 422.

524. **EDUCATION IN COMMUNIST COUNTRIES (2-3)** Educational policies and practices in Soviet Russia and other Communist countries. Prerequisite: C.F.Ed. 422 or 6 credits in Russian or Asian studies.

526. **EDUCATION IN DEVELOPING COUNTRIES (2-3)** Educational problems and trends in selected countries, with particular reference to Africa, the Middle East, and Southeast Asia. Prerequisite: C.F.Ed. 422 or 6 credits in Asian, African, or Latin-American studies.

532. **SOCIAL CHANGE, CULTURAL DYNAMICS, AND EDUCATION (2-3)** The social role of the school in a rapidly changing society. Prerequisite: C.F.Ed. 416.

534. **READINGS IN PHILOSOPHY OF EDUCATION (1-6)** Selected philosophic writings — classic, modern, or contemporary — on education. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

536. **EDUCATIONAL LEADERS AND CLASSICS (2-3)** Selected leaders and their writings, with emphasis on historical-social context, including Quintilian, Erasmus, Comenius, Fénelon, Pestalozzi, and Mann.

592. **SEMINAR IN CULTURAL FOUNDATIONS OF EDUCATION (1-9)** Conferences and discussions designed to meet the need for special study of particular areas in cultural foundations of education. Prerequisites: 12 credits of graduate work in cultural foundations of education.

EARTH AND MINERAL SCIENCES (EM SC)

420. (S.T.S. 420) **ENERGY AND MODERN SOCIETY (3)**

421. (S.T.S. 421) **MATERIALS AND MODERN SOCIETY (3)**

596. **INDIVIDUAL STUDIES (1-6)**

EAST ASIAN STUDIES (EA ST)

401. **EAST ASIAN STUDIES (3-6)**

ENGINEERING (ENGR)

410. (S.T.S. 410) **TECHNOLOGY: ITS CHARACTER, ROLE, AND FUNCTION (3)**

450. **PATENT FUNDAMENTALS (3)**

500. **SPECIAL TOPICS IN ENGINEERING (1-3)**

ENGINEERING SCIENCE (E SC)

- 400. ELECTROMAGNETIC FIELDS (3)
- 401. SENIOR DESIGN PROJECT (2)
- 402. SENIOR DESIGN PROJECT (2)
- 403. SENIOR DESIGN PROJECT (3)
- 404. ANALYSIS IN ENGINEERING SCIENCE (3)
- 405. ENGINEERING APPLICATIONS OF FIELD THEORY (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501. SOLID STATE ENERGY CONVERSION (3) Principles of solid state energy conversion and their utilization in engineering devices. Emphasis on current research and development efforts. Prerequisite: E.E. 419 or Phys. 412. *Mr. Fonash*

ENVIRONMENTAL RESOURCE MANAGEMENT (E R M)

- 400. SENIOR SEMINAR (1)
- 410. POLLUTION OF ENVIRONMENTAL SYSTEMS (3)
- 411. LEGAL ASPECTS OF RESOURCE MANAGEMENT (3)
- 412. RESOURCE SYSTEMS ANALYSIS (3)
- 413. CASE STUDIES IN ECOSYSTEM MANAGEMENT (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

FOLKLORE (FOLK)

- 400. THEORY AND TECHNIQUES OF FOLKLORE (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

GERONTOLOGY

In several programs students may select gerontology or adult development and aging as an area of specialization — in the behavioral and social sciences, in the biological sciences, and in certain professional programs. No major or degree in gerontology is offered. Information may be obtained from the Gerontology Center, S-211 Henderson Human Development Building.

HEALTH PLANNING AND ADMINISTRATION (H P A)

- 410. PRINCIPLES OF PUBLIC HEALTH ADMINISTRATION (3)
- 420. ENVIRONMENTAL HEALTH (3-6)
- 430. PRINCIPLES OF HEALTH PLANNING (3)
- 431. HEALTH PLANNING METHODS (3)
- 432. HEALTH SYSTEMS MANAGEMENT (3)
- 433. HEALTH SYSTEMS THEORY (3)
- 440. EPIDEMIOLOGIC BASIS FOR PLANNING (3)
- 445. (Econ. 445) HEALTH ECONOMICS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

HUMAN DEVELOPMENT (H DEV)

- 401. PROFESSIONAL ISSUES IN HUMAN DEVELOPMENT (1-3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 499. SENIOR THESIS (1-10)

516. METHODS OF RESEARCH IN HUMAN DEVELOPMENT (1-6) Review of problems and techniques of research in human development.

517. MULTIVARIATE STUDY OF CHANGE AND HUMAN DEVELOPMENT (3) Models of development and change derived from empirical research utilizing multivariate research design and procedures. Prerequisites: at least three statistics courses, including correlation and regression analysis.

HUMANITIES (HUMAN)

471. HUMANISTIC STUDIES (1-4)

490. (C.&S. 490) HUMANITIES FOR TEACHERS (3)

INTERDISCIPLINARY PROGRAM IN THE HUMANITIES

Qualified students who wish to receive a Ph.D. degree in one of the graduate major programs in the College of the Liberal Arts or the College of Arts and Architecture, and yet would like to receive an interdisciplinary education, may enter the interdisciplinary program in the humanities after they have been properly enrolled in one of the major programs, provided their interdisciplinary interest lies within the realm of the humanities.

INTERNATIONAL UNDERSTANDING (INT U)

400. WORLD AFFAIRS AND INTERNATIONAL UNDERSTANDING (3-6)

ITALIAN (IT)

415. DANTE (3)

420. PETRARCA AND BOCCACCIO (3)

425. THE LITERATURE OF THE ITALIAN RENAISSANCE (3)

450. NINETEENTH-CENTURY ITALIAN LITERATURE (3)

460. TWENTIETH-CENTURY ITALIAN LITERATURE (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

588. SEMINAR IN ITALIAN LITERATURE (3-12) Common and individual research in special problems.

JAPANESE (JAPNS)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

LABOR STUDIES (L S)

400. COMPARATIVE INDUSTRIAL RELATIONS SYSTEMS (3)

404. COLLECTIVE BARGAINING TRENDS (3)

411. TRADE UNION ADMINISTRATION (3)

413. (Econ. 413) COMPARATIVE LABOR MOVEMENTS (3)

414. (Econ. 414) THEORIES OF THE LABOR MOVEMENT (3)

433. (Pl.Sc. 433) THE LAW OF LABOR-MANAGEMENT RELATIONS (3)

435. LABOR RELATIONS IN THE PUBLIC SECTOR (3)

437. IMPASSE RESOLUTION IN LABOR RELATIONS (3)

454. (Soc. 454) INDUSTRY AND THE COMMUNITY (3)

455. (Soc. 455) THE SOCIOLOGY OF WORK (3)

458. (Hist. 458) HISTORY OF AMERICAN ORGANIZED LABOR SINCE 1877 (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

LANDSCAPE ARCHITECTURE (LARCH)

- 431. LANDSCAPE DESIGN — AREA ANALYSIS (3)
- 432. LANDSCAPE DESIGN — SITE ANALYSIS (3)
- 433. LANDSCAPE DESIGN — DETAIL ANALYSIS (3)
- 434. PARK FACILITY PLANNING AND EVALUATION (3)
- 435. LANDSCAPE CONSTRUCTION MATERIALS (3)
- 437. BASIC LANDSCAPE CONSTRUCTION (3)
- 439. ADVANCED LANDSCAPE CONSTRUCTION (3)
- 441. LANDSCAPE DESIGN — DETAIL DESIGN (3)
- 442. LANDSCAPE DESIGN — AREA DESIGN (3)
- 443. LANDSCAPE DESIGN — SITE DESIGN (3)
- 444. LANDSCAPE ARCHITECTURE FIELD TRIP (1)
- 451. COMPREHENSIVE LANDSCAPE DESIGN I (4)
- 452. COMPREHENSIVE LANDSCAPE DESIGN II (4)
- 453. COMPREHENSIVE LANDSCAPE DESIGN III (4)
- 457. PROFESSIONAL PRACTICE (2)
- 458. ADVANCED LANDSCAPE COMMUNICATIONS (2)
- 471. PARK PLANNING THEORY AND CONCEPTS (2)
- 472. PLANNING AND PUBLIC POLICY (3)
- 473. RECREATION RESOURCE PLANNING (3)
- 474. SITE ENGINEERING FUNDAMENTALS (1)
- 475. PARK SYSTEMS PRACTICUM (1)
- 491. LANDSCAPE SEMINAR I (1)
- 492. LANDSCAPE SEMINAR II (1)
- 493. LANDSCAPE SEMINAR III (1)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 499. FIELD EXPERIENCE (1-3)

518. ADVANCED PROBLEMS IN LANDSCAPE DESIGN (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects.

521. TECHNICAL LANDSCAPE ARCHITECTURAL PRACTICES (2-12) Specific technical and professional problems in landscape architectural planning and practice.

LAW ENFORCEMENT AND CORRECTIONS (L E C)

- 401. PROBATION, PAROLE, AND PARDONS (3)
- 410. CORRECTIONAL COUNSELING PROCESSES (3)
- 420. SPECIAL OFFENDER TYPES (3-6)
- 430. CORRECTIONAL INSTITUTIONS AND SERVICES (3)
- 440. FUNDAMENTAL TECHNIQUES OF SCIENTIFIC CRIMINAL INVESTIGATION (3)
- 441. YOUTH AND LAW ENFORCEMENT (3)
- 460. HISTORY AND FUNCTION OF CRIMINAL JUSTICE COMPONENTS (3)
- 470. LAW OF CRIMES AND CORRECTIONS (3)
- 471. LEGAL RIGHTS, DUTIES, LIABILITIES OF CRIMINAL JUSTICE PERSONNEL (3)
- 480. RESEARCH METHODS IN ADMINISTRATION OF JUSTICE (3)
- 482. SEMINAR, CRIMINAL JUSTICE AGENCY ADMINISTRATION (3)
- 490. ADVANCED FIELD WORK IN ADMINISTRATION OF JUSTICE (4)
- 491. FIELD WORK IN ADMINISTRATION OF JUSTICE (2)
- 492. PROFESSIONAL FIELD THESIS IN ADMINISTRATION OF JUSTICE (4)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

LIBERAL ARTS (L A)

- 460. UNDERGRADUATE INTERNSHIP (1-6)
- 461. ACADEMIC ADVISER TRAINING (1)
- 480. (S.T.S. 480) TECHNOLOGICAL CHANGE AND HUMAN VALUES (3)
- 482. QUANTITATIVE METHODS FOR HUMANISTS I (3)
- 483. QUANTITATIVE METHODS FOR HUMANISTS II (3)
- 484. (Engl. 484) COMPUTATIONAL AND QUANTITATIVE STYLISTICS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

LITHUANIAN (LITH)

- 500. STRUCTURE OF LITHUANIAN (3) Analysis of the phonology, morphology, and syntax of Lithuanian; comparative linguistic study of Balto-Slavic and Indo-European. Prerequisite: one graduate course in linguistics.

MATERIALS SCIENCE (MATSC)

- 401. MATERIALS SCIENCE FOR TEACHERS I (3)
- 402. MATERIALS SCIENCE FOR TEACHERS II (3)
- 404. PROCESS MEASUREMENT AND CONTROL (1-3)
- 406. INTRODUCTION TO BIOMEDICAL MATERIALS (3)
- 408. (G.Sc. 408) X-RAY DIFFRACTION (3)
- 411. (G.Sc. 411) INSTRUMENTAL TECHNIQUES APPLIED TO MATERIALS AND MINERAL SCIENCE PROBLEMS (1-6)

Unit A. X-RAY DIFFRACTION

Unit B. TRANSMISSION ELECTRON MICROSCOPY

Unit C. SPECTROSCOPY

Unit D. ELECTRON MICROPROBE ANALYSIS

Unit E. SCANNING ELECTRON MICROSCOPY

Unit F. ABSORPTION SPECTROSCOPY

- 412. QUANTITATIVE MICROSTRUCTURAL AND PARTICULATE CHARACTERIZATION (1)
- 416. MATERIALS PREPARATION (2)
- 420. MATHEMATICAL MODELING FOR MATERIALS SCIENTISTS (3)
- 490. SPECIAL TOPICS IN MATERIALS SCIENCE (1-9)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. THERMODYNAMICS OF MATERIALS (3) Application of thermodynamics to materials equilibria and processes, including solution theory, electrochemical processes, capillarity, and the effect of stresses. Prerequisite: Chem. 451.

- 503. (G.M. 503) KINETICS OF MATERIALS PROCESSES (3) Introduction to application of transition state theory and mass transfer to the kinetics of materials and mineral processes. Prerequisites: Math. 100; Chem. 451; Mat.Sc. 501 or G.M. 521.

- 512. (G.M. 512) PRINCIPLES OF CRYSTAL CHEMISTRY (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions.

- 514. CHARACTERIZATION OF MATERIALS (3) Classical and new (microprobe, scanning microscope, magnetic resonance, and Mossbauer) techniques for the characterization of composition, structure, defects, and surfaces.

- 524. (G.M. 524) VIBRATIONAL SPECTRA OF MATERIALS AND MINERALS (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization, and glass research. Prerequisites: Phys. 412, 471.

- 531. (G.M. 531) TRANSMISSION ELECTRON MICROSCOPY (2) Discussion of electron image contrast

theory as a tool for study of atomic substructures in the materials and mineral sciences. Prerequisite: Mat.Sc. 411B (Min. 411B).

532. (G.M. 532) STRUCTURE ANALYSIS (2) Crystal structure determination methods; space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Mat.Sc. 408 (G.Sc. 408).

533. (G.M. 533) SINGLE CRYSTAL METHODS (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Mat.Sc. 408 (G.Sc. 408).

534. (G.M. 534) DIFFRACTION BY CRYSTALS (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescence, polarization. Prerequisite: Mat.Sc. 408 (G.Sc. 408).

535. (G.M. 535) GEOMETRICAL CRYSTALLOGRAPHY (3) Derivation of lattices, types, point groups, and space groups, with applications.

538. (G.M. 538) ELECTRON BEAM ANALYSIS OF SOLIDS VIA X-RAY AND ELECTRON EMISSION (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids.

540. CRYSTAL ANISOTROPY (3) Symmetry aspects of crystals and physical properties. Matrix and tensor methods. Prerequisite: Phys. 412.

542. MAGNETIC METHODS IN MATERIALS SCIENCE (3) Static magnetic (susceptibility type) and spectroscopic methods (nuclear and electron magnetic resonance, Mossbauer spectroscopy) for materials characterization and structural analysis. Prerequisite: Phys. 413.

552. THEORY AND PRACTICE OF CRYSTAL GROWTH (3) Theoretical approaches to crystal growth and of the various techniques used in growing crystals.

554. ELECTRONIC SPECTRA OF MATERIALS (3) Crystallographic and thermodynamic applications of crystal field theory. Electronic spectra of crystals and glasses. Luminescent spectra and phosphor characterization. Prerequisite: Phys. 471.

564. STRUCTURE AND PROPERTIES OF CARBONS AND GRAPHITE (3) Relation of the ideal and defect structure of polycrystalline carbons and graphite to their mechanical, electronic, thermal, and optical properties. Prerequisite: Phys. 412.

570. CATALYTIC MATERIALS (3) Preparation and characterization of solid catalytic materials. Relationships between their surface, defect, and electronic properties and catalytic activity. Prerequisite: Chem. 452.

597. SPECIAL TOPICS (1-6)

MINERAL ENGINEERING (MIN E)

414. PLANNING AND CONTROL FOR THE MINERAL INDUSTRIES (3)

415. MANAGEMENT IN THE MINERAL INDUSTRIES FOR ENVIRONMENTAL, LEGAL, AND HEALTH AND SAFETY PROBLEMS (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

PATHOLOGY (PATH)

501. PRINCIPLES OF PATHOLOGY (4) The fundamentals of reaction to injury at cellular and tissue levels emphasizing the pathogenesis of functional, structural, and biochemical abnormalities.

520. BIOLOGY OF NEOPLASIA (3) Detailed examination of the initiation and pathogenesis of animal neoplasms with emphasis on the relationship to human neoplasia. Prerequisite: admission to College of Medicine.

522. CANCER IMMUNOLOGY AND IMMUNOTHERAPY (2) Detailed study of recent advances in host response to malignancy in man and experimental animals. Prerequisite: Path. 501 or Micrb. 554.

PEDIATRICS (PED)

525. CLINICAL GENETICS (5-10) Mendelian and molecular principles of human genetics; genetic bases of human disease, quantitative human genetics, prenatal diagnosis, genetic counseling.
526. HUMAN CYTOGENETICS (2) Human chromosome identification; structure, replication, and evolution of human and other eukaryotic chromosomes in cytogenetic and molecular terms.

PLANT SCIENCE (PLTSC)

400. PRINCIPLES OF PLANT SCIENCE RESEARCH (2)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

POLYMER SCIENCE (PLMSC)

400. POLYMERIC MATERIALS (3)
406. INTRODUCTION TO THE MATERIALS SCIENCE OF POLYMERS (3)
407. TECHNOLOGY AND APPLICATIONS OF POLYMERIC MATERIALS (3)
409. INTRODUCTION TO PROPERTIES OF POLYMERIC MATERIALS (3)
410. POLYMER-BASED COMPOSITE MATERIALS (3)
411. SMALL ANGLE X-RAY SCATTERING (2)
412. POLYMERIC MATERIALS LABORATORY — SYNTHESIS (2)
413. POLYMERIC MATERIALS LABORATORY — CHARACTERIZATION (2)
490. POLYMER SCIENCE SEMINAR
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
520. POLYMER CRYSTALS (2) Morphology, characterization, and properties of polymer crystals. Review of electron microscopy, thermal analysis, X-ray density, and chemical degradation studies. Prerequisite: Plm.Sc. 407 or 409.
521. POLYMER VIBRATIONAL SPECTROSCOPY I (3) The description, theory, and application of infrared and Raman spectroscopies as applied to polymeric materials. Prerequisites: Math. 71; Chem. 33 or Plm.Sc. 406.
522. POLYMER VIBRATIONAL SPECTROSCOPY II (3) The theory and application of normal coordinate analysis as applied to polymeric materials. Prerequisites: Math. 101; Cmp.Sc. 101 or 201.
560. PROPERTIES OF POLYMERIC MATERIALS (3) Macroscopic and microscopic behavior of polymeric materials. Interpretation of properties in terms of structure. Prerequisite: Plm.Sc. 406.
565. POLYMERIC BIOMEDICAL MATERIALS (3) Synthetic high polymers: their properties and uses in biomedical applications.

POPULATION ISSUES

Qualified students may select population issues studies as an option of specialization when majoring in economics, geography, sociology, anthropology, rural sociology, or agricultural economics. Additional information is given under the description of those majors in the preceding section.

PORTUGUESE (PORT)

456. BRAZILIAN LITERATURE IN ENGLISH TRANSLATION (3)
588. SEMINAR IN PORTUGUESE AND BRAZILIAN LITERATURE (3-12) Common and individual research in special problems.

SAFETY EDUCATION (SAFED)

- 449. SAFETY EDUCATION (3)
- 450. VISUAL AND OTHER AIDS IN SAFETY EDUCATION (3)
- 451. TEACHING TRAFFIC SAFETY AND AUTOMOBILE OPERATION (3)
- 452. ORGANIZATION AND SUPERVISION IN SAFETY EDUCATION (3)
- 453. MOTOR VEHICLE LAW (3)
- 454. LEISURE TIME VEHICLE SAFETY EDUCATION (3)
- 455. TEACHING SAFE MOTORCYCLE OPERATION (3)
- 496, 496v. INDEPENDENT STUDIES (1-12)
- 497, 497v. SPECIAL TOPICS (1-6)

SCIENCE (SC)

- 400. CONSEQUENCES OF SCIENCE (1)

SCIENCE, TECHNOLOGY, AND SOCIETY (S T S)

- 410. (Engr. 410) TECHNOLOGY: ITS CHARACTER, ROLE, AND FUNCTION (3)
- 420. (E.M.Sc. 420) ENERGY AND MODERN SOCIETY (3)
- 421. (E.M.Sc. 421) MATERIALS AND MODERN SOCIETY (3)
- 430. FOOD AND MAN: TECHNOLOGY AND FEEDING THE WORLD POPULATION (3)
- 432. (Phil. 432) MEDICAL ETHICS (3)
- 435. (Phil. 435) THE INTERRELATION OF SCIENCE, PHILOSOPHY, AND RELIGION (3)
- 450. TECHNOLOGICAL CHANGE: ITS PRODUCTION, DIFFUSION, AND IMPACT (3)
- 460. SCIENCE AND PUBLIC POLICY (3)
- 470. TECHNOLOGY ASSESSMENT AND INDICATORS OF THE QUALITY OF LIFE (3)
- 471. RADIATION, REACTORS, AND SOCIETY (3)
- 480. (L.A. 480) TECHNOLOGICAL CHANGE AND HUMAN VALUES (3)
- 496. INDEPENDENT STUDIES (1-12)

NOTE: This program is designed to examine critically the impact of scientific investigation and technological development on society and the influence of human needs on scientific investigation and technological development.

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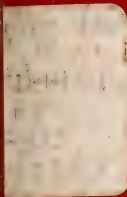
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1979-1980

The Pennsylvania State University Bulletin

Graduate Degree Programs



Note: On July 14, 1979, after this catalog had been printed, the Board of Trustees of The Pennsylvania State University approved increases in tuition and fees. The new figures are below and replace comparable figures on page 50:

TOTAL TUITION FOR EACH TERM

At the University Park Campus and The Milton S. Hershey Medical Center (Nonmedical students) — 8 or more credits, total charge of \$527 for Pennsylvanians and \$1,050 for non-Pennsylvanians; 7 or fewer credits, \$66 per credit for Pennsylvanians and \$131 for non-Pennsylvanians.

At Behrend College, Radnor Graduate Center, and Capitol Campus — 8 or more credits, total charge of \$480 for Pennsylvanians and \$1,050 for non-Pennsylvanians; 7 or fewer credits, \$55 per credit for Behrend College, \$60 per credit at Capitol and Radnor, for Pennsylvanians; \$131 per credit at all locations for non-Pennsylvanians.

Note that these increases also will change the total estimated costs shown on page 58.

The University reserves the right to revise the schedule of tuition and fees without further notice.

1979-1980

**THE PENNSYLVANIA
STATE UNIVERSITY**

GRADUATE DEGREE PROGRAMS

**GENERAL CATALOG
SEPTEMBER 1979**

Address Inquiries to:
Graduate School Information Center
The Pennsylvania State University
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REGULATIONS SUBJECT TO CHANGE

The educational process necessitates change. This bulletin must be considered as informational and not binding on the University.

Each step of the educational process, from admission through graduation, requires continuing review and appropriate approval by University officials. The University, therefore, reserves the right to change the requirements and regulations contained in this bulletin and to determine whether a student has satisfactorily met its requirements for admission or graduation, and to reject any applicant for admission for any reason the University determines to be material to the applicant's qualification to pursue higher education.

GRADUATE CALENDAR*

FALL TERM 1979

JULY 1979

- 30 Monday — Last date for a prospective graduate student to submit completed application materials for admission to the fall term 1979
- 30 Monday — Last date for a graduate student to apply for permission to resume study in the fall term 1979

AUGUST

- 29-31 Wednesday noon to Friday — Fall term registration

SEPTEMBER

- 3 Monday — Labor Day holiday
- 4 Tuesday — Fall term classes begin 8:00 A.M.
- 7 Friday — Last date for registering with foreign language departments (other than French and Spanish) for written language examinations
- 17 Monday — Last date for a November graduate to activate diploma card in Record's Office *and* to pay thesis fee at Bursar's Office
- 21 Friday — Last date for applying for Graduate School tuition grant-in-aid for winter term 1980
- 25 Tuesday — Last date for written foreign language examinations (other than French and Spanish) for advanced-degree candidates
- 28 Friday — Last date for applying for 1980 study-abroad (Fulbright) awards
- 29 Saturday — Last date for a November graduate to deliver doctoral thesis to committee

OCTOBER

- 6 Saturday — Last date for final oral doctoral examinations for November graduates
- 6 Saturday — Last date for a November graduate to deliver master's thesis or paper to adviser
- 22 Monday — Last date for a November graduate to deliver thesis to Graduate School
- 22 Monday — Last date for departments to certify to Graduate School completion of required papers for November graduates
- 22 Monday — Last date for a November graduate to order cap, gown, and hood locally

NOVEMBER

- 10 Saturday — Last date for submitting a petition to the Records Office to graduate *in absentia* in November
- 12 Monday — Fall term classes end 9:55 P.M.
- 13-17 Tuesday to Saturday noon — Final examinations
- 22 Thursday — Thanksgiving Day holiday
- 25 Sunday — Commencement

*This calendar is subject to change without notice. In preparing the calendar for an academic year, the University makes every effort to avoid conflicts with religious holidays. However, such conflicts are sometimes unavoidable. When they occur, efforts are made to make special arrangements for the students affected.

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Examination Services, 207 Mitchell Building. Times and places of tests will be announced when the application is filed.

WINTER TERM 1980

OCTOBER 1979

- 29 Monday — Last date for a prospective graduate student to submit completed application materials for admission to the winter term 1980
- 29 Monday — Last date for a graduate student to apply for permission to resume study in the winter term 1980

NOVEMBER

- 27, 28 Tuesday, Wednesday — Winter term registration
- 29 Thursday — Winter term classes begin 8:00 A.M.

DECEMBER

- 5 Wednesday — Last date for registering with foreign language departments (other than French and Spanish) for written language examinations
- 10 Monday — Last date for a March graduate to activate diploma card in Record's Office and to pay thesis fee at Bursar's Office
- 19 Wednesday — Winter term recess begins 9:55 P.M.

JANUARY 1980

- 2 Wednesday — Winter term recess ends
- 3 Thursday — Winter term classes resume 8:00 A.M.
- 4 Friday — Last date for written foreign language examinations (other than French and Spanish) for advanced-degree candidates
- 4 Friday — Deadline for applying for Graduate School tuition grant-in-aid for spring term 1980
- 5 Saturday — Last date for a March graduate to deliver doctoral thesis to committee
- 12 Saturday — Last date for final oral doctoral examinations for March graduates
- 12 Saturday — Last date for a March graduate to deliver master's thesis or paper to adviser
- 28 Monday — Last date for a March graduate to deliver thesis to Graduate School
- 28 Monday — Last date for departments to certify to Graduate School completion of required papers for March graduates
- 28 Monday — Last date for a March graduate to order cap, gown, and hood locally

FEBRUARY

- 1 Friday — Deadline for applying for fellowships through any of the Graduate School programs
- 15 Friday — Last date for submitting a petition to the Records Office to graduate *in absentia* in March
- 20 Wednesday — Winter term classes end 9:55 P.M.
- 21-23, 25 Thursday to Saturday, Monday — Final examinations

MARCH

- 1 Saturday — Commencement

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Examination Services, 207 Mitchell Building. Times and places of tests will be announced when the application is filed.

SPRING TERM 1980

FEBRUARY 1980

- 6 Wednesday — Last date for a prospective graduate student to submit completed application materials for admission to the spring term 1980
- 6 Wednesday — Last date for a graduate student to apply for permission to resume study in the spring term 1980

MARCH

- 6, 7 Thursday, Friday — Spring term registration
- 10 Monday — Spring term classes begin 8:00 A.M.
- 14 Friday — Last date for registering with foreign language departments (other than French and Spanish) for written language examinations
- 24 Monday — Last date for a May graduate to activate diploma card in Record's Office and to pay thesis fee at Bursar's Office
- 29 Saturday — Last date for a May graduate to deliver doctoral thesis to committee

APRIL

- 1 Tuesday — Last date for written foreign language examinations (other than French and Spanish) for advanced-degree candidates
- 4 Friday — Deadline for applying for Graduate School tuition grant-in-aid for summer term 1980 and fall term 1980
- 5 Saturday — Last date for final oral doctoral examinations for May graduates
- 5 Saturday — Last date for a May graduate to deliver master's thesis or paper to adviser
- 21 Monday — Last date for a May graduate to deliver thesis to Graduate School
- 21 Monday — Last date for departments to certify to Graduate School completion of required papers for May graduates
- 21 Monday — Last date for a May graduate to order cap, gown, and hood locally

MAY

- 16 Friday — Last date for submitting a petition to the Records Office to graduate *in absentia* in May
- 17 Saturday — Spring term classes end 12:25 P.M.
- 19-22 Monday to Thursday — Final examinations
- 31 Saturday — Commencement

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Examination Services, 207 Mitchell Building. Times and places of tests will be announced when the application is filed.

SUMMER TERM 1980

MAY 1980

- 12 Monday — Last date for a prospective graduate student to submit completed application materials for admission to the summer term 1980
- 12 Monday — Last date for a graduate student to apply for permission to resume study in the summer term 1980

JUNE

- 10 Tuesday — Summer term registration
- 11 Wednesday — Summer term classes begin 8:00 A.M.
- 17 Tuesday — Last date for registering with foreign language departments (other than French and Spanish) for written language examinations
- 23 Monday — Last date for an August graduate to pay thesis fee at Bursar's Office *and* to activate diploma card in Record's Office

JULY

- 4 Friday — Independence Day holiday
- 5 Saturday — Last date for an August graduate to deliver doctoral thesis to committee
- 8 Tuesday — Last date for written foreign language examinations (other than French and Spanish) for advanced-degree candidates
- 12 Saturday — Last date for final oral doctoral examinations for August graduates
- 12 Saturday — Last date for an August graduate to deliver master's thesis or paper to adviser
- 28 Monday — Last date for an August graduate to deliver thesis to Graduate School
- 28 Monday — Last date for departments to certify to Graduate School completion of required papers for August graduates
- 28 Monday — Last date for an August graduate to order cap, gown, and hood locally

AUGUST

- 15 Friday — Last date for submitting a petition to the Records Office to graduate *in absentia* in August
- 20 Wednesday — Summer term classes end 9:55 P.M.
- 21-23 Thursday to Saturday — Final examinations
- 30 Saturday — Commencement

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Examination Services, 207 Mitchell Building. Times and places of tests will be announced when the application is filed.

FALL TERM 1980

AUGUST 1980

- 8 Friday — Last date for a prospective graduate student to submit completed application materials for admission to the fall term 1980
- 8 Friday — Last date for a graduate student to apply for permission to resume study in the fall term 1980

SEPTEMBER

- 3-5 Wednesday noon to Friday — Fall term registration
- 8 Monday — Fall term classes begin 8:00 A.M.
- 12 Friday — Last date for registering with foreign language departments (other than French and Spanish) for written language examinations
- 22 Monday — Last date for a November graduate to pay thesis fee at Bursar's Office and to activate diploma card in Record's Office
- 30 Tuesday — Last date for written foreign language examinations (other than French and Spanish) for advanced-degree candidates

OCTOBER

- 4 Saturday — Last date for a November graduate to deliver doctoral thesis to committee
- 11 Saturday — Last date for final oral doctoral examinations for November graduates
- 11 Saturday — Last date for a November graduate to deliver master's thesis or paper to adviser
- 27 Monday — Last date for a November graduate to deliver thesis to Graduate School
- 27 Monday — Last date for departments to certify to Graduate School completion of required papers for November graduates
- 27 Monday — Last date for a November graduate to order cap, gown, and hood locally

NOVEMBER

- 14 Friday — Last date for submitting a petition to the Records Office to graduate *in absentia* in November
- 15 Saturday — Winter term classes end 12:25 P.M.
- 17-21 Monday to Friday noon — Final examinations
- 27 Thursday — Thanksgiving Day holiday
- 29 Saturday — Commencement

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Examination Services, 207 Mitchell Building. Times and places of tests will be announced when the application is filed.

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 RONALD J. TEICHMAN, Ph.D. (Northwestern) *Asst. Prof. of Acctg. and Management Info. Systems*
 CRAIG D. TENNEY, Ph.D. (Indiana) *Assistant Professor of Journalism*
 RICHARD B. TENSER, M.D. (S.U.N.Y.) *Assistant Professor of Medicine and Microbiology*
 DANIEL R. TERSHAK, Ph.D. (Yale) *Associate Professor of Microbiology*
 ROBERT C. TETRAULT, Ph.D. (Wisconsin) *Associate Professor of Entomology Extension*
 MARY J. TEVETHIA, Ph.D. (Michigan State) *Associate Professor of Microbiology*

SATVIR S. TEVETHIA, Ph.D. (Michigan State) *Professor of Microbiology*
 HELEN M. THAL, Ed.D. (Columbia) *Professor of Home Economics Education*
 GEORGE A. THEODORSON, Ph.D. (Cornell) *Professor of Sociology*
 BARBARA A. THERRIEN, M.N. (Washington) *Assistant Professor of Nursing*
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 DENO G. THEVAOS, Ed.D. (Columbia) *Professor of Education and Psychology*
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 HOWARD W. THOELE, Ph.D. (Minnesota) *Associate Professor of Dairy Science*
 HOBEN THOMAS, Ph.D. (Claremont) *Professor of Psychology*
 HORACE R. THOMAS, JR., Ph.D. (Vanderbilt) *Assistant Professor of Civil Engineering*
 CARL I. THOMPSON, Ph.D. (Wisconsin) *Associate Professor of Behavioral Science*
 DONALD E. THOMPSON, Ph.D. (Penn State) *Research Associate at Applied Research Laboratory*
 JAMES G. THOMPSON, Ph.D. (Penn State) *Associate Professor of Physical Education*
 KEITH P. THOMPSON, Ph.D. (Case Western Reserve) *Assoc. Professor of Music Education*
 MARVIN P. THOMPSON, Ph.D. (Michigan State) *Adjunct Professor of Food Science*
 WILLIAM THOMPSON, JR., Ph.D. (Penn State) *Asst. Professor of Acoustical Mechanics*
 DENNIS W. THOMSON, Ph.D. (Wisconsin) *Professor of Meteorology*
 CHARLES P. THORNTON, Ph.D. (Yale) *Professor of Petrology*
 PETER A. THROWER, Ph.D. (Cambridge) *Associate Professor of Materials Science*
 GEORGE L. THUERING, M.S. (Penn State), M.E., P.E. *Professor of Industrial Engineering*
 THOMAS T. THWAITES, Ph.D. (Rochester) *Associate Professor of Physics*
 JIRI TICHY, Ph.D. (Prague Inst. of Tech.) *Professor of Architectural Engineering*
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 EMILY TOTH, Ph.D. (Johns Hopkins) *Assistant Professor of English*
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 T. A. TOUSSOUN, Ph.D. (California) *Adjunct Professor of Plant Pathology*
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 ALFRED TRAVERSE, Ph.D. (Harvard) *Professor of Palynology*
 NANCY J. TREAT, Ph.D. (West Virginia) *Asst. Prof. of Indiv. and Family Studies*
 ROBERT TREHY *Professor of Music*
 RICHARD E. TRESSLER, Ph.D. (Penn State) *Associate Professor of Ceramic Science*
 MARIETTA J. TRETTER, Ph.D. (Wisconsin) *Assistant Professor of Management Science*
 ALFRED A. TRIOLO, Ph.D. (Illinois) *Associate Professor of Spanish and Italian*
 CECIL R. TRUEBLOOD, D.Ed. (Penn State) *Professor of Education*
 FREDERICK C. TRUTT, Ph.D. (Delaware) *Associate Professor of Electrical Engineering*
 IGNATIUS SIU TUNG TSONG, Ph.D. (London) *Research Associate, Materials Research Lab.*
 TIEN-TZOU TSONG, Ph.D. (Penn State) *Professor of Physics*
 ALBERT G. TSUGAWA, Ph.D. (Michigan) *Associate Professor of Philosophy*
 SHALOM TSUR, Ph.D. (Hebrew, Jerusalem) *Assistant Professor of Computer Science*
 LOREN D. TUKEY, Ph.D. (Ohio State) *Professor of Pomology*
 BRIAN J. TURNER, D.For. (Yale) *Associate Professor of Forest Management*
 JAMES B. TURPEN, Ph.D. (Tulane) *Assistant Professor of Biology*
 RICHARD D. TWARK, Ph.D. (Penn State) *Assoc. Prof. of Quantitative Business Analysis*
 BEN W. TWIGHT, Ph.D. (Washington) *Associate Professor of Forest Resources*
 JOHN E. TYWORTH, Ph.D. (Oregon) *Assistant Professor of Business Logistics*
 JAMES S. ULTMAN, Ph.D. (Delaware) *Associate Professor of Chemical Engineering*
 RAYMOND E. UNTRAUER, Ph.D. (Illinois), P.E. *Professor of Civil Engineering*
 RICHARD F. UNZ, Ph.D. (Rutgers) *Associate Professor of Sanitary Microbiology*
 M. LEE UPCRAFT, Ph.D. (Michigan) *Assistant Professor of Education*

- HUGH B. URBAN, Ph.D. (Penn State) *Professor of Human Development and Psychology*
 PETER D. USHER, Ph.D. (Harvard) *Associate Professor of Astronomy*
 S. V. UTECHIN, Dr.Phil. (Kiel, Germany) *Professor of Russian History*
 THEODORE R. VALLANCE, Ph.D. (Syracuse) *Professor of Human Development*
 E. MICHAEL VAN BUSKIRK, M.D. (Boston) *Assistant Professor of Surgery*
 BETTY VAN DER SMISSEN, Re.D. (Indiana) *Professor of Recreation*
 DAVID B. VAN DOMMELEN, M.A. (Michigan State) *Professor of Art Education*
 JUDITH VAN HERIK, Ph.D. (Chicago) *Assistant Professor of Religious Studies*
 JAMES E. VAN HORN, Ph.D. (Ohio State) *Associate Prof. of Family Sociology Ext.*
 MARGUERITE H. VANLANDINGHAM, Ph.D. (Florida) *Assistant Professor of Finance*
 M. ALBERT VANNICE, Ph.D. (Stanford) *Associate Professor of Chemical Engineering*
 ROBERT C. VANNUCCI, M.D. (Jefferson) *Assistant Professor of Pediatrics*
 FRANCIS J. VASTOLA, Ph.D. (Penn State) *Professor of Fuel Science*
 ELMER A. VASTYAN, B.D. (Episcopal Theol., Cambridge) *Prof. of Human. and Rel. Studies*
 CARL G. VAUGHT, Ph.D. (Yale) *Associate Professor of Philosophy*
 KUPPUSWAMY VEDAM, Ph.D. (Indian Institute of Science) *Professor of Physics*
 DONALD P. VERENE, Ph.D. (Washington) *Associate Professor of Philosophy*
 ELLIOT S. VESELL, M.D. (Harvard) *Professor of Pharmacology, Genetics, and Medicine*
 JOSEPH J. VILLAFRANCA, Ph.D. (Purdue) *Associate Professor of Chemistry*
 WILLIAM A. VOGELY, Ph.D. (Princeton) *Professor of Mineral Economics*
 BARRY VOIGHT, Ph.D. (Columbia) *Professor of Geology*
 ROY S. VOLLMER, M.Arch. (Pennsylvania) *Associate Professor of Architecture*
 DAVID R. VOLTMER, Ph.D. (Ohio State) *Assistant Professor of Electrical Engineering*
 HELEN B. VOLZ, Ph.D. (Penn State) *Assistant Professor of Special Education*
 FRED W. VONDRACEK, Ph.D. (Penn State) *Associate Professor of Human Development*
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 JOHN S. WADE, JR., Ph.D. (Tennessee) *Associate Professor of Engineering*
 JAMES S. WAKELEY, Ph.D. (Utah State) *Assistant Professor of Wildlife Ecology*
 DWAIN N. WALCHER, M.D. (Chicago) *Professor of Human Development*
 DANIEL WALDEN, Ph.D. (New York) *Professor of American Studies*
 JOHN A. WALDHAUSEN, M.D. (St. Louis School of Medicine) *Professor of Surgery*
 PHILIP L. WALKER, JR., Ph.D. (Penn State) *Evan Pugh Professor of Materials Science*
 STEPHEN J. WALLNER, Ph.D. (Iowa State) *Assistant Professor of Horticultural Physiology*
 WALTER H. WALTERS, Ph.D. (Case Western Reserve) *Professor of Theatre Arts*
 HAROLD V. WALTON, Ph.D. (Purdue) *Professor of Agricultural Engineering*
 JAMES C. WAMBOLD, Ph.D. (New Mexico) *Assoc. Professor of Mechanical Engineering*
 MIAN-CHANG WANG, Ph.D. (California) *Associate Professor of Civil Engineering*
 PAUL J. WANGSNESS, Ph.D. (Iowa State) *Associate Professor of Animal Nutrition*
 PATRICIA A. WARD, Ph.D. (Wisconsin) *Assoc. Prof. of French and Comparative Literature*
 WILBER W. WARD, D.For. (Yale) *Professor of Silviculture*
 ROGER P. WARE, Ph.D. (California) *Associate Professor of Mathematics*
 REX H. WARLAND, Ph.D. (Iowa State) *Professor of Rural Sociology*
 PAUL K. WARME, Ph.D. (Illinois) *Assistant Professor of Biochemistry and Biophysics*
 THOMAS T. WARNER, Ph.D. (Penn State) *Assistant Professor of Meteorology*
 JOHN M. WARREN, JR., Ph.D. (Wisconsin) *Professor of Psychology*
 THOMAS WARTIK, Ph.D. (Chicago) *Professor of Chemistry*
 MICHAEL J. WASYLENKO, Ph.D. (Syracuse) *Assistant Professor of Economics*
 WILLIAM C. WATERHOUSE, Ph.D. (Harvard) *Associate Professor of Mathematics*
 LOIS K. WATERS, Ed.D. (Columbia) *Assistant Professor of Nursing*
 THOMAS L. WATSCHKE, Ph.D. (Virginia Polytech.) *Assoc. Professor of Turfgrass Science*
 JAMES R. WATSON, Ph.D. (Illinois) *Associate Professor of Business Administration*
 ROBERT D. WEAVER, Ph.D. (Wisconsin) *Assistant Professor of Agricultural Economics*
 RALPH L. WEBB, Ph.D. (Minnesota) *Associate Professor of Mechanical Engineering*
 HELMUT E. WEBER, Sc.D. (M.I.T.) *Professor of Mechanical Engineering*
 DAVID L. WEBSTER, Ph.D. (Minnesota) *Associate Professor of Anthropology*
 THOMAS C. WEBSTER, Ph.D. (Ohio State) *Assistant Professor of Public Administration*

- FREDERICK C. WEDLER, Ph.D. (Northwestern) *Associate Professor of Biochemistry*
 DANIEL W. WEEDMAN, Ph.D. (Wisconsin) *Professor of Astronomy*
 PAUL D. WEENER, Ph.D. (Michigan) *Associate Professor of Educational Psychology*
 WILLIAM A. WEIDNER, M.D. (Wisconsin) *Professor of Radiology*
 WALTER B. WEIMER, Ph.D. (Minnesota) *Associate Professor of Psychology*
 FREDERICK F. WEINER, Ph.D. (Wayne State) *Associate Professor of Speech Pathology*
 STEVEN M. WEINRED, Ph.D. (Rochester) *Associate Professor of Chemistry*
 STANLEY WEINTRAUB, Ph.D. (Penn State) *Research Professor of English*
 SUSAN F. WEIS, Ph.D. (Penn State) *Assistant Professor of Home Economics Education*
 BORIS WEISFEILER, Ph.D. (Steklov's Math. Institute, Leningrad) *Assoc. Prof. of Mathematics*
 BENO WEISS, Ph.D. (New York) *Associate Professor of Italian*
 JUDITH WEISZ, M.B., B.Chir. (London) *Professor of Obstetrics and Gynecology*
 FREDERICK G. WELCH, D.Ed. (Penn State) *Associate Professor of Vocational Education*
 PAUL W. WELLIVER, Ph.D. (Penn State) *Professor of Education*
 ROBERT WELLS, Ph.D. (Princeton) *Associate Professor of Mathematics*
 WILLIAM A. WELSH, JR., Ph.D. (Illinois) *Associate Professor of Civil Engineering*
 JANE I. WENGER, Ph.D. (Minnesota) *Assistant Professor of Physiology*
 NANCY WENTZLER, Ph.D. (Wisconsin) *Assistant Professor of Economics*
 FREDERICK L. WERNSTEDT, Ph.D. (U.C.L.A.) *Professor of Geography*
 HARRY H. WEST, Ph.D. (Illinois), P.E. *Associate Professor of Civil Engineering*
 PAUL N. WEST, M.A. (Columbia) *Professor of English and Comparative Literature*
 DAVID L. WESTBY, Ph.D. (Michigan State) *Associate Professor of Sociology*
 FRANCIS L. WHALEY, Ph.D. (Michigan) *Associate Professor of Psychology*
 ALFRED G. WHEELER, JR., Ph.D. (Cornell) *Adjunct Assistant Professor of Entomology*
 C. HERBERT WHEELER, JR., M.Arch. (M.I.T.) *Professor of Architectural Engineering*
 EUGENE E. WHITE, Ph.D. (Louisiana State) *Professor of Speech Communication*
 JOHN W. WHITE, Ph.D. (Penn State) *Professor of Horticulture*
 MICHAEL R. WHITE, Ph.D. (Ohio State) *Associate Professor of Industrial Arts Education*
 WILLIAM B. WHITE, Ph.D. (Penn State) *Professor of Geochemistry*
 WILLIAM J. WHITE, M.S. (Penn State) *Assistant Professor of Comparative Medicine*
 CAROL F. WHITFIELD, Ph.D. (George Washington) *Assistant Professor of Physiology*
 GEORGE D. WHITFIELD, Ph.D. (Columbia) *Associate Professor of Physics*
 JAMES O. WHITTAKER, Ph.D. (Oklahoma) *Professor of Psychology and Social Science*
 EDWARD W. WICKERSHAM, Ph.D. (Wisconsin) *Associate Professor of Biology*
 THOMAS A. WIGGINS, Ph.D. (Penn State) *Professor of Physics*
 KENNETH P. WILKINSON, Ph.D. (Mississippi State) *Professor of Rural Sociology*
 JACK H. WILLENBROCK, Ph.D. (Penn State), P.E. *Associate Professor of Civil Engineering*
 ANTHONY V. WILLIAMS, Ph.D. (Michigan State) *Associate Professor of Geography*
 ARTHUR L. WILLIAMS, Ph.D. (Pennsylvania), C.L.U. *Professor of Insurance*
 EUGENE G. WILLIAMS, Ph.D. (Penn State) *Professor of Geology*
 FREDERICK M. WILLIAMS, Ph.D. (Yale) *Associate Professor of Biology*
 ROBERT J. WILLIAMS, Ph.D. (Wisconsin) *Assistant Professor of Mechanical Engineering*
 JANET A. WILLIAMSON, Ph.D. (Penn State) *Associate Professor of Nursing*
 SHERRY L. WILLIS, Ph.D. (Texas) *Assistant Professor of Early Childhood Education*
 FERN K. WILLIS, Ph.D. (Penn State) *Professor of Rural Sociology*
 DONALD J. WILLOWER, Ed.D. (Buffalo) *Professor of Education*
 BRENT G. WILSON, Ph.D. (Ohio State) *Professor of Art Education*
 DAVID T. WILSON, Ph.D. (Western Ontario) *Professor of Marketing*
 GEOFFREY L. WILSON, Ph.D. (Loughborough Tech., England), P.E. *Associate Professor of Engineering Research*
 LOWELL L. WILSON, Ph.D. (South Dakota State) *Professor of Animal Science*
 R. DALE WILSON, Ph.D. (Iowa) *Assistant Professor of Marketing*
 LOUIS WINKLER, Ph.D. (Pennsylvania) *Assistant Professor of Astronomy*
 JERRY L. WIRCENSKI, Ph.D. (Ohio State) *Associate Professor of Vocational Education*
 JOHN WITHALL, Ph.D. (Chicago) *Professor of Education and Educational Psychology*
 FRANCIS H. WITHAM, Ph.D. (Indiana) *Associate Professor of Biology*

- WILLARD E. WITTE, Ph.D. (Wisconsin) *Assistant Professor of Economics*
 WARREN F. WITZIG, Ph.D. (Pittsburgh) *Professor of Nuclear Engineering*
 JOACHIM F. WOHLWILL, Ph.D. (California) *Prof. of Man-Environment Relations and Psychology*
 GEORGE D. WOLF, Ph.D. (Pennsylvania) *Professor of American Studies and History*
 MELVIN H. WOLF, Ph.D. (Michigan) *Professor of Humanities and English*
 CARL H. WOLGEMUTH, Ph.D. (Ohio State) *Professor of Mechanical Engineering*
 IRA WOLINSKY, Ph.D. (Kansas) *Associate Professor of Nutrition*
 FRED H. WOOD, D.Ed. (Missouri) *Professor of Education*
 NORMAN D. WOOD, Ph.D. (Brigham Young) *Assistant Professor of Education*
 DAWN CLAUDIA WOODERSON, Ph.D. (Florida State) *Assistant Professor of Music Education*
 LLOYD W. WOODRUFF, Ph.D. (Minnesota) *Associate Professor of Public Administration*
 PAUL O. WOOLLEY, JR., M.D. (Yale) *Associate Professor of Health Planning*
 DETLEF WOTSCHKE, Ph.D. (California) *Assistant Professor of Computer Science*
 HELEN S. WRIGHT, Ph.D. (Penn State) *Associate Professor of Nutrition*
 JAMES E. WRIGHT, JR., Ph.D. (Cornell) *Professor of Genetics*
 LAUREN A. WRIGHT, Ph.D. (California Tech.) *Professor of Geology*
 PAUL J. WUEST, Ph.D. (Penn State) *Professor of Plant Pathology*
 JOSEPH P. YANEY, Ph.D. (Michigan) *Professor of Business Administration*
 LAKSHAM S. YAPA, Ph.D. (Syracuse) *Associate Professor of Geography*
 RONALD E. YASBEY, Ph.D. (Rochester) *Asst. Professor of Microbiology and Cell Biology*
 THOMAS D. YAWKEY, Ph.D. (Illinois) *Associate Professor of Education*
 WILLIAM G. YENDOL, Ph.D. (Purdue) *Professor of Entomology*
 EDGAR P. YODER, Ph.D. (Ohio State) *Assistant Professor of Agriculture Education*
 BERTRAM YOOD, Ph.D. (Yale) *Professor of Mathematics*
 THOMAS M. YORK, Ph.D. (Princeton) *Professor of Aerospace Engineering*
 CARL E. YOUNG, Ph.D. (George Peabody) *Assistant Professor of Human Development*
 DAVID L. YOUNG, M.L.A. (Harvard) *Professor of Landscape Architecture*
 FREDERICK J. YOUNG, Ph.D. (Carnegie Tech.) *Professor of Electrical Engineering*
 PHILIP YOUNG, Ph.D. (Iowa) *Research Professor of English*
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 CARLOS ZAMORA, Ph.D. (U.C.L.A.) *Assistant Professor of Spanish*
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 ARIAN ZARKOWER, Ph.D. (Cornell) *Associate Professor of Veterinary Science*
 WILBUR ZELINSKY, Ph.D. (California) *Professor of Geography*
 ROBERT F. ZELIS, M.D. (Chicago) *Professor of Medicine and Physiology*
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 VICKIE L. ZIEGLER, Ph.D. (Yale) *Associate Professor of German*
 LEONARD N. ZIMMERMAN, Ph.D. (Cornell) *Professor of Bacteriology*
 RICHARD E. ZINDLER, Ph.D. (Michigan State) *Professor of Engineering Research*
 HARRY D. ZOOK, Ph.D. (Penn State) *Professor of Chemistry*
 GEORGE S. ZORETICH, M.A. (Penn State) *Professor of Art*

GENERAL INFORMATION

THE GRADUATE SCHOOL

Graduate work at The Pennsylvania State University was first offered in 1862, but for some time there were few graduate students and graduate instruction was relatively unorganized. A committee of the General Faculty eventually was given the responsibility of establishing standards and regulations governing graduate work and the granting of master's and certain technical degrees. The Graduate School was formally established in 1922 by the President and the Board of Trustees. An administrative staff was organized, and the Graduate Faculty was formed. The University Senate delegated to this faculty responsibility for graduate affairs, subject to review. In 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy. On May 9, 1971, a Graduate Council was established for the Graduate School. Today graduate study is offered in 124 major programs, with 17 advanced academic and professional degrees being conferred. During the academic year 1977-1978, 5,800 to 6,200 graduate students were enrolled each term, and 1,779 advanced degrees were conferred, of which 346 were doctorates.

The Graduate School is a member of the Association of Graduate Schools (an organization within the Association of American Universities) and of the Council of Graduate Schools in the United States.

MAJOR ROLE

The major role of the Graduate School is to emphasize those aspects of University activity which pertain directly to major programs in graduate study. Through its Graduate Faculty it represents a large segment of the academic strength of the University and is thus a dominant force in sustaining and furthering the intellectual quality of the entire institution. The eleven colleges of the University formulate study and research programs appropriate to their fields. The Graduate Faculty consists of those members of the college faculties who have authorization through the Graduate School to offer courses and seminars and supervise research and theses consistent with the highest academic standards. Thus, the Graduate School may be regarded as a federation of selected segments of the college faculties.

GOVERNANCE

The governance of the Graduate School is vested in a Graduate Council, whose legislative authority is subject to the specific restrictions of the "Articles of Authority." The council forms its own committee structure under bylaws outlined in "Standing Rules of the University Graduate Council."

Executive and administrative matters of the Graduate School are the responsibility of the dean, who is charged directly with enforcement of the regulations of the Graduate School and with organization of its administrative procedures. The dean has a major responsibility to enhance and insure the high quality of graduate study and research of graduate students. He exercises leadership in initiating new programs and in restructuring or phasing out marginal and obsolete ones. The dean encourages and assists in the development of multidisciplinary programs. He is assisted in this work by an administrative and clerical staff.

ADMINISTRATIVE DIVISIONS

There are four major administrative divisions in the Graduate School to which the students may go directly for answers to questions which require administrative assistance or decisions:

1. *Graduate Admissions*, 201 Kern Graduate Building. The Office of Graduate Admissions has responsibility for processing all matters pertaining to a student's admission.
2. *Graduate Student Programs*, 211 Kern Graduate Building. The functions of the Office of Graduate Student Programs encompass responsibilities for the academic involvement and concerns of all graduate students from the time they are admitted until they graduate, such as: (a) registration of students, (b) readmission of students, (c) maintenance of records, (d) appointment of graduate committees for doctoral students, (e) scheduling of graduate student comprehensive examinations, (f) checking for accomplishment by students of Graduate Fac-

ulty requirements for all advanced degrees and preparation of official commencement lists, and (g) attention to student academic problems.

3. *Graduate Fellowships*, 320 Kern Graduate Building. The Office of Graduate Fellowships serves as a clearinghouse for information on available fellowships and other awards for graduate students, administers fellowships and other award programs involving students in more than one college, and seeks support for graduate students attending the University.
4. *Theses and Publications*, 320 Kern Graduate Building. The Office of Theses and Publications is responsible for reviewing all theses to assure that they meet format requirements consistent with the attainment of high scholarly standards. The office prepares the major Graduate School publications.

PROGRAMS AT OTHER LOCATIONS

Behrend College — The Behrend College at Erie provides convenient opportunity for graduate education to persons residing in northwestern Pennsylvania. It has been established to offer individual courses and a program leading to the degree of Master of Engineering with a major in engineering science.

Radnor Center for Graduate Studies — The Radnor Center for Graduate Studies near Philadelphia offers programs leading to the degrees of Master of Engineering with majors in engineering science and industrial engineering, and Master of Education with a major in mathematics.

The Capitol Campus — The Capitol Campus, located near Middletown and named for its proximity to the state capital, was opened in 1966. Graduate programs leading to the degrees of Master of Administration, Master of Arts with majors in American studies and in humanities, Master of Education with a major in teaching and curriculum, Master of Engineering with a major in engineering science, Master of Psychosocial Science, Master of Public Administration, and Master of Regional Planning with a major in urban and regional planning are currently offered.

The Milton S. Hershey Medical Center — The University's Medical Center was established in 1963, and the first class of medical students entered in the fall of 1967. The center is located in Hershey, Pennsylvania, twelve miles from Harrisburg. In conjunction with The Pennsylvania State University's Graduate School, the College of Medicine offers programs leading to the Master of Science degree with a major in laboratory animal medicine, and to the Doctor of Philosophy and Master of Science degrees with majors in anatomy, biological chemistry, microbiology, pharmacology, and the intercollege programs in genetics and physiology.

KERN GRADUATE BUILDING

The Kern Graduate Building is named in honor of the late Dean Emeritus Frank D. Kern, who was the first dean of the Graduate School. The Graduate School administrative offices are on the second and third floors of the building.

GRADUATE COMMONS

The Graduate Commons, located on the first floor of Kern Graduate Building, provides programs, services, and facilities for the graduate community and serves as a common meeting area for faculty and students. The assembly room and multipurpose rooms are used for large group meetings; the smaller

rooms are used for committee meetings and similar small group gatherings. These may be reserved by graduate organizations or for events of a University-wide nature.

Food service is provided by the Department of Housing and Food Service in the cafeteria and for special catered events. The lobby contains the Commons Gallery, which displays artwork done by students and faculty and exhibits from sources outside the University. The Commons serves as the home for Graduate Student Association programs such as the coffeehouse, films, concerts, and similar events. Policy governing building use and services is determined by the Graduate Council Committee on Graduate Commons and Related Matters.

The Office of the Director of the Graduate Commons serves as a clearinghouse for the scheduling of events planned by organizations and individuals. Reservations, a periodicals lending library (including daily newspapers), information regarding Graduate Commons activities, recreational equipment, and information of a general nature concerning the Graduate School are available at the Graduate Commons Information Desk. The Commons is open seven days a week during the term session. The operating hours are posted at building entrances. For further information call the Information Desk at 865-1878.

INTERNATIONAL STUDENT AFFAIRS

The Office of International Student Affairs (OISA) and the International Student Lounge are located in 111 Kern Graduate Building. There are approximately 1,200 international students from 100 countries studying at the various University campuses. The majority of these students are enrolled in graduate programs.

Services of OISA include: assistance with immigration regulations and tax information; academic, financial, and personal/social counseling; emergency loans; program advising; mail service; housing information; job and travel information; job information in home countries; an international student newsletter; and sponsorship of many clubs and activities.

The International Student Lounge is a comfortable place for international and American students to meet informally. All students are welcome to participate in OISA activities. Announcements of events are posted regularly in the lounge. OISA maintains a library of overseas work/study/travel information, as well as other educational reading materials, including dictionaries, encyclopedias, maps, arts and crafts books, and many newspapers and magazines from around the world. The lounge and conference room are available for group meetings upon request.

The OISA works closely with the Community International Hospitality Council, a local community volunteer organization, and the International Council, a student organization which represents international students to the University administration and promotes a variety of social, cultural, and educational programs for the University community.

GRADUATE STUDENT ASSOCIATION

The Graduate Student Association was established in 1951 as the representative body for graduate students, all of whom are automatically members, and is charged with designating graduate student representatives to a number of committees throughout the University. This volunteer organization provides graduate students with services, programs, and activities not otherwise available through the University. It also provides occasions for relaxation through its social programs. To help defray expenses, the association is partially funded through an allocation from Associated Student Activities, which is under the direction of the assistant vice president for student programs.

The Graduate Student Association Council, the legislative arm of the association, consists of elected delegates from every graduate department, with voting rights proportionate to the number of students in the department. Also included as voting *ex officio* members are the graduate students who have been elected to serve on the University Faculty Senate (4), the Graduate Council (5), and the University Council (1). All members of the University community are invited to attend the regular monthly meetings of the Association Council. An Executive Board, which consists of the executive officers and di-

vision heads, has interim powers to conduct business not requiring the specific action of the Association Council. The executive officers act as official liaison between the association and the dean of the Graduate School.

The Graduate Student Association has an office in 305 Kern Graduate Building (Tel. 865-9061). It has established the following divisions and standing committees: *Service Division* (1) Housing Committee, (2) Publication Committee, (3) Health Committee, (4) Tax Committee, and (5) Orientation Committee; *Programming/Planning Division* (1) Coffeehouse Committee, (2) Film Committee, (3) Speakers and Workshop Committee, and (4) Special Events Committee; *Academic Division*; and *Rules Committee*.

In addition, the Association Council may institute *ad hoc* committees and presidential commissions at will. Graduate students are eligible to serve on all committees of the Graduate Council.

The association maintains communication among its members through the campus daily newspaper, scheduled meetings and workshops, and informal use of the Graduate Commons. It publishes annually the *Guide to Graduate Life*, an informal introduction to both the University and the community.

FACILITIES

THE UNIVERSITY LIBRARIES

The University Libraries include a central collection, four subject branch libraries, and one reading room at University Park. Libraries are also located at Hershey Medical Center, Capitol Campus, Radnor Graduate Center, Behrend College, and at each of the seventeen two-year campuses.

At University Park, the central collection, the Arts Library, and the Life Sciences Library are all housed in the Fred Lewis Pattee Library. There are four branch libraries serving the Colleges of Earth and Mineral Sciences, Engineering, Science, and the Department of Mathematics; one reading room in the Department of Architecture; and the Pollock Library in an undergraduate dormitory area.

Included in the central collection are general reference books and periodicals, works in agriculture, biology, education and psychology, economics and business, the humanities, the natural and social sciences, maps, manuscripts, and government documents. Among special collections are the Penn State Collection, a Joseph Priestley and a John O'Hara Collection, labor history archives, Audio Archives Collection, Australian and Utopian literature, the Allison-Shelley Collection of Anglica Americana Germanica, music cassettes, microforms, and a rare book collection. Housed in Pattee Library is the Penntap Information System, which serves industries, municipalities, and businesses in the Commonwealth. In the reading room and special branch libraries are books and journals needed for work assigned in the Colleges mentioned above. A library handbook for students is available at the Information Desk on the main floor of Pattee. As a part of regularly scheduled University courses, instruction in the use of library resources will be provided, upon request, by library faculty. General library orientation tours are offered at the beginning of each term. Computerized literature searches of selected data bases in engineering, earth and mineral sciences, and in the physical, social, and life sciences are available through the General Reference Section and the related branch libraries.

The University Libraries are a member of numerous cooperative groups. They are one of the four Regional Library Resource Centers as established by Pennsylvania law and have memberships in the Union Library Catalogue of Pennsylvania, the Association of Research Libraries, the Mid-Atlantic Research Libraries Information Network, the Associated College Libraries of Central Pennsylvania, and the Pittsburgh Regional Library Center.

The libraries have approximately 2,160,000 catalogued volumes, 997,000 government documents, 24,000 serials, 208,000 maps, 2,000,000 microforms, 2,800 music cassettes, and about 2,000,000 other bibliographical items. Among the special resource guides issued by the library are *Newspapers in Microform*, *Pennsylvania Maps and Atlases*, *Serial Holdings in The Pennsylvania State University Libraries at University Park*, and *Guide to Sources in Black Studies in The Pennsylvania State University Libraries*. The library also issues *Voices and Events*, a catalogue of audio tapes recorded on the University Park Campus.

COMPUTATION CENTER

The Computation Center is actively engaged in evaluating and developing modern computing trends and computer systems to meet current job and research needs. Organized as a separate unit under the University Intercollege Programs, the Computation Center provides computing tools and technical services that aid in the education and research programs of all academic departments. Its facilities are heavily used by more than 4,000 graduate students and faculty engaged in research, and by 10,000 undergraduate students doing class assignments; the Computation Center routinely processes more than 15,000 separate computer jobs per day. Computer hardware includes a modern six-megabyte IBM 3033 Processor Complex, about three billion bytes of disk storage, a ten-thousand-reel tape library, and a large configuration of other input/output and telecommunications equipment. Current computer software includes a large repertoire of modern programming language compilers and several thousand library programs. There are sixty-five machine-readable data bases available, including 300 magnetic tape volumes of census data. Access to the computer system can be obtained through high-speed batch terminals (ten on campus, and twenty-two at the two-year colleges). Typewriter terminals may also access the computer system through either the APL time-sharing facility, or the Penn State Remote Job Entry file system. Except for a few holidays, the Computation Center is open for job processing twenty-four hours a day, seven days a week.

The Computation Center faculty and staff conduct group tours, computer programming workshops, technical seminars, and guest lectures to acquaint the University community with its services and with advances in computing practices. Computation Center programming consultants provide advice and technical assistance for using library programs, and advice for programming and debugging new applications. Extensive documentation in all areas of related service and programming is provided for graduate students and faculty. The Computation Center offers assistantships to qualified graduate students enrolled in any curriculum. A more detailed summary of facilities and services may be found in the publication *Introduction to the Computation Center*, available in 214 Computer Building.

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus and within comfortable walking distance of most of the campus, provide one- and two-bedroom apartments for graduate students with families.

The Eastview Terrace apartments are fire-resistant, steel-framework, one-story buildings. There are forty-six one-bedroom units and thirty two-bedroom units. Rent includes utilities except for electricity, telephone, and TV cable. Water is heated electrically. The units are unfurnished except for electric stove and refrigerator. For each two units, there is a utility room with two stationary laundry tubs and storage space. Privately owned automatic washers may be installed in apartment kitchens only. No coin-operated facilities are available.

Graduate Circle has 144 one-bedroom apartments and 72 two-bedroom apartments in sixteen two-story buildings of brick and frame construction. Rent includes all utilities except for telephone and TV cable. Each kitchen has a double stainless steel sink with disposal unit, a gas stove, kitchen cabinets, and an electric refrigerator. One bedroom has a built-in chest of drawers; otherwise, the units are unfurnished. There are no facilities for private washing machines in the apartments; however, coin-operated laundries at nominal fees are provided in five of the buildings throughout the area. A basement storage locker is provided for each apartment.

Residence in Graduate Circle or Eastview Terrace Graduate Family Apartments is limited to registered full-time graduate students who are candidates for advanced degrees. All students must live with their spouse and/or preschool children in the apartment. Families with children of school age (including kindergarten) or with children who will come of school age during the term of the lease cannot be considered for occupancy. The one-bedroom units are designed for a graduate student and spouse, and the two-bedroom units for a family with not more than two children. Rates and additional information can be obtained from the Assignment Office for Campus Residences, 101 Shields Building, University Park, PA 16802. Telephone: (814) 865-7501

Atherton Hall, located near the Hetzel Union Building, and McKee Hall, located near the Kern Graduate Building, are residence halls which provide combined room and board accommodations for single graduate men and women. Most assignments are made to double rooms since single rooms are available for only one out of three students. Rates for room and board for these halls can be obtained from the Assignment Office.

All rates are subject to change by action of the University.

Information on other living accommodations available in the community may be obtained through:

The Graduate Student Association
305 Kern Graduate Building
The Pennsylvania State University
University Park, Pennsylvania 16802
Phone: (814) 865-9061

The Organization of Town Independent Students
20 Hetzel Union Building
The Pennsylvania State University
University Park, Pennsylvania 16802
Phone: (814) 865-6851

The State College Area Chamber of Commerce
131 Sowers Street
State College, Pennsylvania 16801
Phone: (814) 237-7644

Graduate students should arrange for their accommodations well in advance of the beginning of classes, because it may be very difficult to find convenient housing at the last minute. **STUDENTS MUST BE ADMITTED TO THE GRADUATE SCHOOL BEFORE THEIR REQUESTS FOR ON-CAMPUS LIVING ACCOMMODATIONS CAN BE PROCESSED.**

STUDENT SERVICES

The facilities and services outlined in the following paragraphs are available to graduate students.

UNIVERSITY HEALTH SERVICES

Located in the central campus area, the Ritenour Health Center is the core of the health service activities and is composed of a dispensary and a hospital. Its facilities are available to full-time graduate students qualifying for nonacademic student benefits and privileges; that is, students registered for 6 or more credits or the equivalent (students holding quarter-time, half-time, or three-quarter-time assistantships.) *The outpatient dispensary handles student medical problems from 8:00 a.m. until 4:45 p.m. daily except Saturdays, when hours are from 8:00 a.m. to 11:45 a.m. During other periods, including Sundays and holidays, patients are seen for emergencies only in the Emergency Room of the University Hospital, which is part of the Health Center complex. There is a \$7.50 emergency charge per visit.

The University Hospital is well equipped to handle the more serious illnesses and injuries on an inpatient basis. A twenty-five-bed facility, it is staffed with professional personnel twenty-four hours a day during the school terms. Should the need arise for special medical or surgical treatment — major surgery, for example — the student will be transferred to a personally chosen hospital facility.

Included in the Health Center facilities are a dental office for emergency dental care, a physiotherapy department, a pharmacy, and a nutrition clinic.

Hospitalized students will be charged \$35 per day during confinement, and a nominal charge will be made for X-rays and all drugs dispensed to hospital or dispensary patients. Consultation with or treat-

*Eligibility is determined by the Graduate School when the I.D. cards are issued.

ment by physicians other than the professional staff at the Health Center is at the student's expense. All accounts should be settled before the end of the term in which charges were incurred.

The Ritenour Health Center maintains an ambulance service for local transportation of students with nonambulatory illnesses and injuries.

HEALTH INSURANCE

Comprehensive, low-cost medical insurance is available for full- and part-time graduate students and their dependents. Information concerning the specifics of the policy can be obtained by contacting the Graduate Student Association, 305 Kern Graduate Building, University Park, PA 16802 (Tel. 865-4211).

MEDICAID BENEFITS

Graduate students may qualify for most of the benefits that apply to hospitalization and medical treatment under Medicaid. Graduate students who are permanent residents of Centre County may apply for state medical assistance to the Office of the Centre County Board of Assistance, Bellefonte, PA 16823 (Tel. 355-5531).

HEALTH SERVICES FOR CHILDREN

Many medical services are available for children under twenty-one through the State Health Center. The services range from simple immunizations to complicated surgery. Diagnostic study and consultation at the center are made regardless of the ability to pay; however, not all services are free. Children may be referred to the center by physicians or health and welfare agencies. Any preschool child is eligible for free well-child examinations and immunizations. For additional information, contact the Health Center at 110 South School Street, Bellefonte, PA 16823 (Tel. 355- 5438), or consult your doctor.

CAREER DEVELOPMENT AND PLACEMENT CENTER

The center functions as both a counseling and placement service for students. Its primary purpose is to serve students, both individually and in groups, by assisting them through career and educational counseling in formulating immediate and long-range career plans.

The center cooperates with the colleges and departments of the University to assist students in implementing career plans upon graduation. Services include: (1) a library containing information on career opportunities, employer characteristics, and graduate and professional schools; (2) scheduled interviews with prospective employers who are visiting the campus; (3) a file of employment opportunities for which a student may apply by mail; (4) a listing of career-related summer jobs and internships; (5) workshops in interviewing skills, résumé preparation, and job search strategies; (6) a variety of informational meetings and publications; and (7) credential services for candidates seeking positions in educational institutions.

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

University Park Campus and Medical Center (Nonmedical Students) — 8 or more credits, total charge of \$484 for Pennsylvanians and \$944 for non-Pennsylvanians; 7 or fewer credits, \$60 per credit for Pennsylvanians and \$118 for non-Pennsylvanians. These rates apply also to off-campus research and other approved individual study.

Behrend College, Radnor Graduate Center, and Capitol Campus — 8 or more credits, total charge of \$411 for Pennsylvanians and \$944 for non-Pennsylvanians; 7 or fewer credits, \$47 per credit at Behrend, \$51 per credit at Radnor and Capitol, for Pennsylvanians; \$118 per credit at all locations for non-Pennsylvanians.

Continuing Education Center — Tuition for continuing education courses carrying graduate credit will be charged at the prevailing rate at the campus where the courses are offered.

Vocational Education Program — 8 or more credits, total charge of \$484 for Pennsylvanians and \$944 for non-Pennsylvanians; 7 or fewer credits, \$60 per total program for Pennsylvanians and \$118 for non-Pennsylvanians (vocational education courses are indicated by "v" following the course number).

Tuition is the same for courses whether audited or taken for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of \$25. A student whose account is delinquent for more than ten days is subject to suspension from the University.

When it appears that an applicant for admission is not domiciled in Pennsylvania, a non-Pennsylvanian classification is assigned. If the student who is thus admitted believes that circumstances do not justify classification as a non-Pennsylvanian, a petition can be made to the Financial Officer for the Dean of the Graduate School, 316 Kern Graduate Building, University Park, PA 16802, for reclassification. (See Student Pennsylvania Resident Status, page 63.)

All tuition costs are subject to change.

TUITION REFUND POLICY

Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the Office of Graduate Student Programs and presents it, together with a current Certificate of Registration, at the Office of the Fee Assessor no later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term, in accordance with the following schedule:

Refund of 80 percent upon withdrawal before the end of the first week of the term (seventh consecutive calendar day from the first day of classes) and a decrease of 20 percent for each week thereafter, up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIFIC CHARGES

In addition to the foregoing tuition and charges, the following charges apply under special conditions and are to be paid independently:

Application fee	\$20.00
Change of schedule, each change	2.00
Duplicate meal ticket	2.00
Duplicate student identification and activity card	each 5.00
Music, individual lessons	40.00 to 100.00

Privilege of late payment.....	25.00
Privilege of late registration	10.00
Special Ph.D. thesis preparation registration fee (601, 611)	118.00
Student parking fee, each term.....	10.00
Teacher placement service registration fee.....	10.00
Teacher placement service reactivation fee	10.00
Thesis microfilming and binding fee for master's candidate (one copy)	12.50
Thesis microfilming and binding fee for doctoral candidate (one copy).....	40.00
Transcript of records (with seal), each copy	2.00
Mailing diploma in absentia.....	5.00

A student's transcript, diploma, or both, may be withheld until any outstanding financial obligations to the University have been paid.

MOTOR VEHICLE CHARGES

Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) while at the University is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no registration charge for students who do not desire campus driving or parking privileges. Failure to register a vehicle renders a student liable for a fine of \$15 for each offense or a magistrate's citation.

A permit allowing limited driving and parking on the campus throughout the week costs \$10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only \$3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles. A graduate assistant receiving no fee decals must present the owner's card for the vehicle each term. Pennsylvania registration of all motor vehicles is required if the student lives for more than thirty consecutive days of the year in Pennsylvania. A student's spouse may be required to register his or her car in Pennsylvania. A *Student Parking and Traffic Regulations* booklet is available in Room 209, Hetzel Union Building.

Bicycles — A bicycle is defined as a two-wheeled vehicle propelled by human power. All bicycles operated on the University Park Campus or in the surrounding community must be registered once each year. Expiration date is May 31. Registration may be obtained at the Department of University Safety, 12 Grange Building, Monday through Friday between 8:00 a.m. and 5:00 p.m. Rules and regulations are available at the time of registration.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if acceptance is indicated before April 15, will have complete freedom through April 15 to submit in writing a resignation of the appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits the student to not accept another appointment without first obtaining a formal release.

Selection of recipients of all University awards is made without regard to the sex, race, religious belief, or ethnic origin or handicap or age of the applicant, as provided by law.

ASSISTANTSHIPS

Approximately 2,200 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some major programs. An appointee may serve as an assistant in classroom or laboratory instruction, in research, or in other work.

A prospective student should write directly to the person in charge of the intended graduate major program for information and application forms. Appointments are made subject to the student's admission to the Graduate School as a degree candidate. Clear evidence of superior ability and promise is required. Reappointment to an assistantship is based on availability of positions and the quality of the student's work. In most departments or major programs the number of appointment renewals is limited. A common policy is to limit eligibility to two calendar years of study for a master's candidate or five total years for a doctoral candidate.

The assistantships vary as follows:

QUARTER-TIME—The student normally schedules 7-9 credits per term, receives a stipend in the range \$184-280 per month plus a grant-in-aid of resident education tuition, and is assigned tasks requiring a maximum of 120 hours per term (e.g., ten hours of effort per week for twelve weeks).

HALF-TIME—The student normally schedules 5-7 credits per term, receives a stipend in the range \$368-560 per month plus a grant-in-aid of resident education tuition, and is assigned tasks requiring a maximum of 240 hours per term (e.g., twenty hours of effort per week for twelve weeks).

THREE-QUARTER-TIME—The student normally schedules 4-5 credits per term, receives a stipend in the range \$552-840 per month plus a grant-in-aid of resident education tuition, and is assigned tasks requiring a maximum of 360 hours per term (e.g., thirty hours of effort per week for twelve weeks).

The credit load limits specified above may be increased or decreased for a specific term by permission of the assistantship supervisor, provided the total work load is properly balanced in each term and the total credit load over a series of terms is in conformity with the specified limits stated above. Work assigned as a part of assistantship duties for which academic credit is granted need not be counted as a part of the credit limits stated above.

In addition to receiving a grant-in-aid to cover tuition during the term of appointment, a graduate assistant completing three or more consecutive terms of appointment is entitled to a grant-in-aid of tuition for the immediately succeeding term if a scholarship or fellowship is not received from another source for the term. To receive this privilege a student must obtain an Earned Extra Grant-in-Aid Form from the head of the department or program in which the assistantship was held and must follow the instructions on the form in making application.

A graduate assistant may accept concurrent employment outside the University only with permission from the assistantship department head and the assistant's graduate academic program chairman. Concurrent employment normally may not be held with the University. A student may receive a concurrent fellowship supplement.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS AND TRAINEESHIPS

About three hundred fellowships and traineeships are awarded annually. Recipients must be superior students and are sometimes required to have completed a certain minimum of graduate work before being eligible for an award. Need is also frequently a consideration. Fellows and trainees are required to carry 8-10 credits of course work each term or the equivalent in research, receive stipends which vary with the awards, and usually receive grants-in-aid of tuition. They may not accept employment during the terms of their appointments (except with special permission for training purposes) nor are they required to render any service to the University. In some cases a recipient will be expected to engage in research in a broad field specified by the donor. There is no sharp distinction between a fellowship and a traineeship. Scholarly excellence is always a major consideration and usually the most important criterion in selecting fellowship recipients. Other considerations commonly come first in awarding traineeships.

GRADUATE SCHOOL FELLOWSHIPS — A number of fellowships, each paying a stipend of up to \$448/month and providing a grant-in-aid to cover resident education tuition charges, are given by the University and are designated as Graduate School Fellowships. They are available to outstanding graduate students working toward a Ph.D., D.Ed., or M.F.A. degree. The ability of applicants being comparable, some preference is given to students majoring in the humanities and social sciences.

Application forms may be obtained from the Graduate School Fellowship Office, 320 Kern Graduate Building. Applications must be submitted through the applicant's graduate major program and must be received by the Graduate School by the first Monday in February to be considered for the following year. Graduate Record Examination verbal, quantitative, and analytical test scores are required of all applicants.

ERIC A. WALKER AND SPECIAL GRADUATE SCHOOL FELLOWSHIPS, FELLOWSHIP SUPPLEMENTS, AND GRANTS-IN-AID — These are open only to students who have been approved for admission but are not yet enrolled in the Graduate School at the time of application. Full fellowships pay up to \$448/month plus resident education tuition. Grants-in-aid provide only tuition. Supplements are small grants in addition to a graduate assistantship or another fellowship. Some supplements are in the form of low-interest loans. Application forms may be obtained from the Fellowship Office, 320 Kern Graduate Building, University Park, PA 16802, and must be submitted through the person in charge of the applicant's graduate major program so as to reach the Graduate School by mid-February to be considered for the following fall. Applicants must arrange to have Graduate Record Examination verbal, quantitative, and analytical test scores sent to the Graduate School by the application deadline.

MINORITY GRADUATE SCHOLARS AWARDS — These are fellowships, assistantships, and fellowship supplements granted as a part of the University's comprehensive educational opportunity program. Stipends and qualifications are the same as for other fellowships and assistantships. For further information contact the Graduate School Fellowship Office, 320 Kern Graduate Building.

FELLOWSHIPS AND TRAINEESHIPS FROM SPECIFIC GRANTS TO DEPARTMENTS AND DIVISIONS BY FOUNDATIONS, INDUSTRIAL CONCERNS, AND FEDERAL AGENCIES — Over 200 such awards, with various stipends, are granted through individual departments and state and national organizations. Information and application forms may be secured from the person in charge of the appropriate graduate major program. The specific awards will vary somewhat from year to year, but the following are typical of those which were available for 1978-79.

ADMINISTRATION ON AGING TRAINEESHIPS — Available to graduate students admitted for study in selected programs; stipend varies. Details available from the Gerontology Center, S-211 Henderson Human Development Building.

AMELIA EARHART FELLOWSHIP — Available to a woman graduate student in Aerospace Engineering; stipend \$4,000.

AMERICAN ACCOUNTING ASSOCIATION FELLOWSHIP — Available to a Ph.D. candidate in accounting; stipend variable up to \$3,000.

AMERICAN CHEMICAL SOCIETY FELLOWSHIPS (2) — Open to graduate students in Geochemistry, Mineralogy, and Solid State Science; stipend \$2,400.

AMERICAN INSTITUTE OF CERTIFIED PUBLIC ACCOUNTANTS FELLOWSHIP — Available to a Ph.D. candidate in accounting; stipend variable up to \$6,600.

AMERICAN PSYCHOLOGICAL ASSOCIATION MINORITY PROGRAM FELLOWSHIPS — Students apply to the Department of Psychology, 417 Moore Building.

ARTHUR ANDERSON & Co. FOUNDATION FELLOWSHIP — Available to a Ph.D. candidate in accounting; stipend variable up to \$5,000.

ASARCO FOUNDATION FELLOWSHIP — Available to a graduate student in Mineral Economics who is interested in writing his or her thesis on nonfuel mineral products, particularly those produced by the donor; stipend \$2,412.

CONTINENTAL OIL COMPANY FELLOWSHIP — Available to a graduate student in Petroleum and Natural Gas Engineering for studies in petroleum engineering; stipend variable.

CONTINENTAL OIL COMPANY FELLOWSHIP IN PETROLEUM ECONOMICS — Available to a graduate student in Mineral Economics for studies in petroleum economics; stipend \$2,056.

COOPERS & LYBRAND FOUNDATION FELLOWSHIP — Available to a Ph.D. candidate in accounting; stipend variable, up to \$5,000.

WHEELER P. DAVEY MEMORIAL FELLOWSHIPS — Available to graduate students in physics; stipend variable.

- DOLomite BRICK CORPORATION GRADUATE FELLOWSHIP**— Available to a graduate student in ceramic science and engineering for research on the thermal/mechanical behavior of dolomite refractories; stipend \$4,000 plus tuition.
- DOMESTIC MINING AND MINERAL AND MINERAL FUEL CONSERVATION FELLOWSHIP**— In support of research in mining and mineral fuel conservation. Open to graduate students in Solid State Science doing research in these fields; stipend \$3,900.
- W. S. ELLIOTT FELLOWSHIP**— Available to a graduate student who is a graduate of The Pennsylvania State University and is interested in engineering research; stipend variable.
- ERNST AND ERNST FELLOWSHIP**— Available to a master's candidate in accounting; stipend \$1,000.
- EXCHANGE TEACHING FELLOWSHIPS IN FRANCE (English Conversation)**— At the University of Strasbourg and the University of Lyon, October-June, renewable. Available to graduate students in French; stipend approximately \$4,700.
- F.I.R.E.**— Research in field of thermal/mechanical behavior of refractories. Available to a student in Ceramic Science; stipend \$3,600 per year.
- HERMAN G. FISHER GRADUATE FELLOWSHIP**— Available to an advanced graduate student in Human Development and Family Studies and especially interested in work with young children; stipend \$3,500 for tuition and other expenses.
- GENERAL FOODS FUND FELLOWSHIPS (2)**— Open to graduate students with a major in the College of Human Development or in Home Economics Education; stipend for doctoral \$3,000, for master's \$2,000, for tuition and other expenses.
- GULF OIL COMPANY FELLOWSHIP IN CHEMICAL ENGINEERING**— Available to a U.S. citizen who is a graduate student in Chemical Engineering; stipend \$3,636.
- GULF OIL COMPANY FELLOWSHIP IN PETROLEUM AND NATURAL GAS ENGINEERING**— Available to a graduate student for work in petroleum production; stipend variable.
- JAMES HAMILTON HARTZELL AND LUCRETIA IRVINE BOYD HARTZELL HISTORY AWARD**— Available to graduate students in History whose field of interest is Pennsylvania history; stipend variable.
- HASKINS AND SELLS FOUNDATION FELLOWSHIP**— Available to a graduate student in accounting; stipend \$2,500.
- WALTER E. HELLER FELLOWSHIP**— Provided by Walter E. Heller & Company, in the amount of \$1,000 for a candidate for the degree of Master of Business Administration.
- HILL FELLOWSHIPS FOR STUDY IN ANTHROPOLOGY OR HISTORY**— Details available from Dean S.F. Paulson of the College of the Liberal Arts, 108 Sparks Building.
- H. R. IMBT SERVICES, INC. FELLOWSHIP**— For graduate work in Civil Engineering in the field of civil engineering construction; stipend \$3,000.
- INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION FELLOWSHIP**— In support of research on the application of lead and zinc compounds to chemical, ceramic, electrical, and allied industries. Available to students in Ceramic Science; stipend \$3,000.
- INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION FELLOWSHIP**— In support of research on the physics and chemistry of lead and zinc compounds. Available to a student in Solid State Science; stipend \$2,540.
- JOSEPH M. JOHNSTON MEMORIAL SCHOLARSHIP**— Available to a student whose program is related to floriculture; stipend variable. Apply through the Department of Horticulture.
- SAMUEL H. KRESS FOUNDATION**— Makes available travel grants and research stipends for American students in art history, architecture, and conservation; for doctoral candidates only.
- MUSEUM INTERNSHIPS**— Available to graduate students in American Studies at the Capitol Campus; stipend varies. Apply to Professor Irwin Richman, Professor in Charge of the Graduate Program in American Studies, Capitol Campus.
- NATIONAL INSTITUTE OF AGING TRAINEESHIPS**— Available to doctoral students in selected graduate programs for research training in adult development and aging; stipend varies. Details available from the Gerontology Center, S-211 Henderson Human Development Building.
- MRS. A. ROBERT NOLL GRADUATE FELLOWSHIP IN APPLIED PHYSIOLOGY**— For graduate research in applied physiology; especially in environmental or exercise physiology; stipend variable.
- NORTON COMPANY FELLOWSHIP**— Available to a graduate student in Ceramic Science for research on thermal/mechanical properties; stipend \$3,600.
- OWENS-ILLINOIS FELLOWSHIP**— Available to a graduate student in Ceramic Science whose thesis is in the area of glass science and technology; stipend \$4,000.

- P.P.&L. POWER PLANT CONSTRUCTION MANAGEMENT GRANT** — Available to a graduate student in Civil Engineering to support a portion of the study phase of a student's graduate work study program with P.P.&L; stipend \$2,500.
- PENNSYLVANIA MEAT PACKERS' ASSOCIATION SCHOLARSHIP** — Open to a selected graduate student specializing in meat science; stipend \$600. Apply through the Department of Dairy and Animal Science.
- PRICE WATERHOUSE FOUNDATION FELLOWSHIP** — Available to a Ph.D. candidate in accounting; stipend variable up to \$5,000.
- JESSE ROSSITER RAPP MEMORIAL SCHOLARSHIP** — Available to graduate students in the School for Forest Resources who are not holding assistantships as graduate students. Apply to the School of Forest Resources' Scholarships, Loans, and Awards Committee.
- RCA CORPORATION FELLOWSHIP** — Available to a graduate student in Electrical Engineering; stipend \$2,500-3,000 for nine months. May be supplemented for an additional three months on application.
- RESCO FELLOWSHIP** — Available to a graduate student in Ceramic Science for research on phosphate-bonded alumina; stipend \$5,000.
- SHAEFFER SCHOLARS PROGRAM** — Provided by Charles W. Shaeffer ('33), retired board chairman, T. Rowe Price Associates, to M.B.A. candidates evidencing strong academic and managerial potential; stipend \$4,000. Apply to director of M.B.A. program.
- J. WALDO SMITH HYDRAULIC FELLOWSHIP** — Established by the American Society of Civil Engineers, Board of Direction, for a graduate student who is preferably an associate member of ASCE. Awarded every third year; \$2,000 for one full academic year, plus a maximum of \$1,000 for research equipment, preferably in the field of experimental hydraulics. More information can be obtained from the Department of Civil Engineering, 212 Sackett Building.
- EDWIN ERLE SPARKS DISSERTATION FELLOWSHIP IN THE HUMANITIES** — Available to a doctoral candidate in one of the following graduate programs: Classics, Comparative Literature, English, French, German, History, Linguistics, Philosophy, Religious Studies, Slavic Languages and Literatures, Spanish, and Speech Communication; stipend \$4,000 plus tuition. Apply to relevant department or program before February 1.
- EDWIN ERLE SPARKS FELLOWSHIPS IN THE HUMANITIES (8)** — Available to beginning graduate students in one of the following graduate programs: Classics, Comparative Literature, English, French, German, History, Linguistics, Philosophy, Religious Studies, Slavic Languages and Literatures, Spanish, and Speech Communication; stipends \$3,000 plus tuition. Apply to relevant department or program before February 1.
- SAMUEL FLETCHER TAPMAN SCHOLARSHIP** — Established by the American Society of Civil Engineers, Board of Direction. Open to any member in good standing of an ASCE student chapter, but no more than three applications may be submitted from the membership of any one student chapter. The sum of each scholarship is \$1,500. More information can be obtained from the Department of Civil Engineering, 212 Sackett Building. Application deadline is December 1.
- TAU BETA PI FELLOWSHIP** — Open to any member of Tau Beta Pi, the engineering honor society, for a year of advanced study. Up to 18 awards of \$3,500 each are available. Applications and information may be obtained from the Office of the Dean, College of Engineering, 101 Hammond Building. Application deadline is February 15.
- TEXACO FELLOWSHIP IN EARTH AND MINERAL SCIENCES** — Available to a graduate student in the College of Earth and Mineral Sciences; stipend \$1,200-3,000 plus tuition.
- WALTER THOMAS MEMORIAL SCHOLARSHIP** — Available to a student studying the nutrition of horticultural crops; stipend variable. Apply through the Department of Horticulture.
- HARRY F. THOMSON SCHOLARSHIP** — Established by the American Concrete Institute for graduate study in the field of concrete. The scholarship is open to any student who is completing studies toward the bachelor's degree or who has received a bachelor's degree from an accredited engineering program. The applicant must be accepted for graduate study of concrete, involving design, materials, construction, or any combination of these subject areas, at a recognized university or college at the time of the award. Information and applications may be obtained from the Department of Civil Engineering, 212 Sackett Building. Application deadline is February 1.
- U.S. OFFICE OF EDUCATION BILINGUAL EDUCATION FELLOWSHIPS** — Available to Ph.D. and D.Ed. candidates preparing for professional careers in bilingual education or a related field; stipend \$3,000-4,700 plus dependency allowance, tuition, books, and fees. Apply to Director, Bilingual Education Program, Division of Curriculum and Instruction, College of Education.

- U.S. OFFICE OF EDUCATION FELLOWSHIPS IN SPEECH PATHOLOGY AND AUDIOLOGY: WORK WITH THE SPEECH-HANDICAPPED; WORK WITH THE DEAF — Open to graduate students specializing in these fields; stipend up to \$1,200-2,400. Apply to the Speech Pathology and Audiology Program.
- U.S. OFFICE OF EDUCATION PUBLIC SERVICE FELLOWSHIPS — Available through the Institute of Public Administration at the University Park Campus and the MPA Program at the Capitol Campus; a stipend of \$3,900 for twelve months and tuition. Fellowships are awarded only to students in the Master of Public Administration degree programs at the Capitol Campus and the University Park Campus.
- U.S. OFFICE OF EDUCATION TRAINEESHIPS IN APPLIED INTERDISCIPLINARY RESEARCH: EARLY CHILDHOOD INTERVENTION — Available for advanced graduate students preparing for careers in research with the young handicapped child; stipend \$2,600-3,200 plus tuition and dependency allowance. Apply to Graduate Program in Human Development and Family Studies.
- U.S. OFFICE OF EDUCATION TRAINEESHIPS IN EDUCATION OF EXCEPTIONAL CHILDREN (28) — Open to graduate students being prepared as leadership personnel in the education of handicapped children; stipend \$300-600 per term plus tuition. Graduate assistantships also available. Apply to the Graduate Admissions Committee, 307 CEDAR Building.
- U.S. OFFICE OF EDUCATION TRAINEESHIPS IN THERAPEUTIC RECREATION — Open to graduate students specializing in therapeutic recreation; stipend \$2,250 (three terms). Apply through the Graduate Program in Recreation and Parks.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS — Available through the Departments of Anthropology, Biological Health, and Man-Environment Relations; stipend \$3,900.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN CLINICAL PSYCHOLOGY (10) — Available through the Department of Psychology; stipend \$2,925 for nine months plus tuition.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN NURSING — Open to selected registered nurse students in nursing; stipend \$3,900 plus tuition. Apply to Professor in Charge, Graduate Program in Nursing.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN RESEARCH ON LIFE SPAN DEVELOPMENT AND THE FAMILY — Open to selected post-master's graduate students in Human Development and Family Studies who are interested in research on the mental health aspects of individual and family development; stipend \$3,900. Apply to Graduate Program in Human Development and Family Studies.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN SOCIAL GERONTOLOGY (12) — Open to selected post-master's graduate students in the social and behavioral sciences; stipend \$2,600-2,800 plus dependency allowance. Apply to Director, Program in Adult Development and Aging, S-110 Henderson Human Development Building.
- U.S. REHABILITATION SERVICES ADMINISTRATION TRAINEESHIPS IN SPEECH PATHOLOGY AND AUDIOLOGY (7) — Open to graduate students specializing in speech pathology and audiology and hearing impaired; stipend up to \$2,400-4,100. Apply to the Speech Pathology and Audiology Program.
- U.S. REHABILITATION SERVICES ADMINISTRATION TRAINEESHIPS IN THERAPEUTIC RECREATION — Open to graduate students specializing in therapeutic recreation; stipend \$1,800 (three terms). Apply through the Graduate Program in Recreation and Parks.
- U.S. REHABILITATION SERVICES ADMINISTRATION TRAINEESHIPS IN VOCATIONAL REHABILITATION COUNSELING — Available to a limited number of graduate students in Counselor Education who are specializing in vocational rehabilitation counseling; tuition plus a stipend of \$675 to \$900 per term. Preference given to minority and handicapped students in awarding traineeships.
- VETERANS ADMINISTRATION INTERNSHIPS IN CLINICAL PSYCHOLOGY — A limited number of internships in veterans administration agencies (hospitals and clinics) are available to graduate students in clinical psychology upon direct application to the agency's chief psychologist with endorsement by the Department of Psychology. Stipend variable.
- ARTHUR YOUNG AND COMPANY FELLOWSHIP — Open to a master's degree candidate in accounting from a predominantly black college. Contact the department in the College of Business Administration.

In addition, grants are available from governmental agencies, industrial concerns, foundations, and the armed forces for graduate study and frequently for support of investigations of particular problems. Some of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from the department of specific interest.

EXTERNALLY SPONSORED FELLOWSHIP AND TRAINEESHIP PROGRAMS — Attention is directed to the following national programs, involving numerous fields of study, with which the University cooperates by providing local administration. (See Statement of Nondiscrimination, page 60.)

FEDERAL HIGHWAY ADMINISTRATION FELLOWSHIPS — Provided by the Federal Highway Administration, U.S. Department of Transportation, to develop the expert manpower needed to carry out state and local jurisdiction highway programs. Open to qualified students for graduate study in traffic engineering and other highway-related areas. Only U.S. citizens are eligible. Fellowships are granted for an academic year at \$6,000 each for tuition, books, and living stipends. Application forms are available from the National Highway Institute, U.S. Department of Transportation, Washington, D.C. 20590.

INTERNATIONAL UNIVERSITY FELLOWSHIPS IN SPACE SCIENCE — These graduate and postdoctoral fellowships are available to foreign nationals who hold the equivalent of Master of Science or Master of Engineering degrees and meet graduate student entrance requirements at United States universities. Details on the program will be found in the brochure concerning these fellowships issued by the Office of Scientific Personnel, National Academy of Sciences, Washington, D.C. 20418.

NATIONAL SCIENCE FOUNDATION FACULTY FELLOWSHIPS — The Graduate School coordinates a program of awards to young college and university teachers (U.S. citizens only) wishing further training or research experience. Awards are made for all or part of a year or for a succession of summer terms. Stipends are related to current academic salary. Application materials may be obtained from the National Science Foundation, Washington, D.C. 20550. The application deadline for 1978 was December 16, 1977.

NATIONAL SCIENCE FOUNDATION GRADUATE FELLOWSHIPS AND MINORITY GRADUATE FELLOWSHIPS — The Graduate School cooperates in this program of prestige fellowships requiring outstanding credentials. These fellowships are available in the biological, engineering, mathematical, physical, and social sciences, as well as the history and philosophy of science. Application is made during the fall to the Fellowship Office, National Academy of Sciences, National Research Council, 2101 Constitution Ave., N.W., Washington, D.C. 20418, which has charge of evaluating applicants for the foundation. The stipend is \$325 per month for three years plus remission of tuition. The application deadline for 1979 was December 8, 1978.

U.S. OFFICE OF EDUCATION MINING AND MINERAL AND MINERAL FUEL CONSERVATION FELLOWSHIPS — Available to individuals in appropriate majors working for M.S. or Ph.D. degrees who are U.S. nationals. Thirty-eight fellowships were awarded in 1978. Award is based on need, significance of planned research, and academic promise. Stipend is \$325 per month. Application procedures are the same as for Graduate School Fellowships. Awards may be supplemented by additional support.

U.S. ENVIRONMENTAL PROTECTION AGENCY FELLOWSHIPS — Available to graduate students who are working in the area of air or water pollution control or potable water production and who are employed by a governmental pollution control agency. Application materials are available from the Grants Administration Division (PM-216), Environmental Protection Agency, Washington, D.C. 20460.

OTHER AIDS

GRADUATE SCHOOL TUITION GRANTS-IN-AID — About forty grants of tuition remission for full-time study are awarded each term. They are available to any graduate degree candidate in the third or later term at the University on criteria of financial need and academic promise. A recipient must carry 8 to 10 credits of graduate work but may accept employment of not more than ten hours per week with the University or another employer. Applications for grants for the winter, spring, and summer terms must be filed by the beginning of the fifth week of the preceding term and by mid-April for the fall term. Application forms may be obtained from the Graduate School Fellowship Office, 320 Kern Graduate Building.

THE RUTH YOUNG BOUCKE GRADUATE FELLOWSHIP — Established from the estate of Ruth Young Boucke, whose husband was for many years a professor of economics, this fellowship is available every other year to an outstanding graduate student on the same basis as the regular Graduate

School fellowships, and selection is made by the Graduate School Committee on Fellowships and Awards. The stipend is up to \$448/mo. plus a grant-in-aid of the \$118 thesis preparation fee.

LOAN AND EMPLOYMENT PROGRAMS — Any prospective or current graduate degree candidate may seek aid from loan and employment programs directly through the Office of Student Aid, 135 Boucke Building. By filing a Financial Aid Form (used to assess a student's financial need) with the College Scholarship Service, Box 176, Princeton, NJ 08540, and by filing an Application for Financial Aid and a Previous Aid Form with the Office of Student Aid, a prospective graduate student will be considered for the following aid programs:

THE NATIONAL DIRECT STUDENT LOAN PROGRAM is a low-interest loan available to United States citizens and permanent residents with a documented financial need, as determined from the Financial Aid Form. Repayment is not necessary until after graduation or termination of graduate work. A schedule of payments will be arranged at that time. Interest begins to accrue nine months after graduation or termination at the rate of 3 percent per year simple interest. Maximum loan for one year is \$2,500.

UNIVERSITY LOANS are funds established by University organizations, alumni, faculty, staff, and friends to help students who have a documented financial need. The borrower is not expected to repay until after graduation or termination of study. Interest begins to accrue immediately upon graduation or termination of study at a 6 percent per year simple interest rate. Maximum loan for one year is \$2,000.

THE COLLEGE WORK STUDY PROGRAM is a form of federal aid awarded to a student with a documented financial need who wishes to earn a portion of his or her aid eligibility through part-time employment. Unlike a loan, there is no repayment, because the student is paid an hourly wage for on-campus employment. Earnings may not exceed the documented need determined for the applicant. For the graduate student with an assistantship agreement, this type of aid is not recommended, since one of the stipulations of the assistantship may prohibit additional employment.

THE GUARANTEED STUDENT LOAN PROGRAM provides low-interest loans (7 percent simple interest per annum) to students enrolled on at least a half-time basis. The loans are repayable after the student graduates or terminates his or her education. This federal financial aid program is a cooperative effort of the federal government, state government and/or guarantor agency, a commercial lending institution, and the educational institution.

An application, including the Lender's Report, should be obtained from a lending institution which agrees to participate with the student in this program. The loan is available on an interest-free basis to all students during their graduate enrollment, regardless of family income. While enrolled, a student's interest payments on the outstanding loan principal are paid by the federal government. A graduate student may borrow up to a total of \$15,000, including any Guaranteed Student Loans received for undergraduate study. Maximum loan for one year is \$5,000.

Additional information for prospective graduate students may be obtained from the Office of Student Aid, 135 Boucke Building, University Park, PA 16802. In corresponding with this office, specify that you are a current or prospective graduate student, and if the latter, the term you wish to begin graduate study at the University.

When seeking aid, the prospective student should keep in mind the following:

Cost of Attendance — In determining a student's need in 1978-79, the Office of Student Aid used the following estimates of expenses for an academic year (three terms) as a basic guide. (Estimates are increased for students with dependents.)

Tuition	\$1,452	(Tuition at Behrend,
Room & Board	1,566	Capitol, and Radnor
Books	240	is \$1,233; tuition
Miscellaneous	876	for non-Pennsylvania-
Total Estimated Costs	\$4,134	nians at all locations is
		\$2,832.)

Nondegree Students — Financial aid is available for graduate students who are degree candidates only. Nondegree graduate students are not eligible.

Summer Term Financial Aid — Students who wish to apply for financial aid for a summer term must file a separate summer Application for Financial Aid with the Office of Student Aid, even if the student received, or will receive, aid for the fall-winter-spring academic year.

The following loans are available only to students in specific graduate programs:

THE U.S. ENVIRONMENTAL PROTECTION AGENCY SPECIAL AIR POLLUTION LOAN FUND has been established through the University's Center for Air Environment Studies. Recipients must be in the terminal year of their program and pursuing a career in air pollution control. Repayment must be completed within three years of graduation. Interest accrues at an annual rate of 3 percent. If the recipient works for two years following graduation for an air pollution control agency, no repayment is required. Apply through the Center for Air Environment Studies.

THE UNITED STATES STEEL FOUNDATION LOAN FUND provides loans for emergencies and to supplement fellowships. Recipients must be U.S. citizens who are enrolled full-time in graduate programs in the colleges of Earth and Mineral Sciences or Engineering. Further information may be obtained from the Graduate School Fellowship Office, 320 Kern Graduate Building.

GIRARD EDU-CHECK PLAN — The University offers to sponsors (including parents) of students the Assured Education Plan, enabling them to pay out of current income, on a monthly basis, University bills for tuition, residence hall room and board, and all other items billed by the University. Life insurance and total and permanent disability insurance are a part of the plan for the sponsor up to the sixty-eighth and sixty-first birthdays, respectively. Payments are handled through the Girard Bank, 1339 Chestnut Street, Philadelphia, PA 19107. Further information and application forms may be obtained from the Office of the University Bursar, 103 Shields Building. Signed agreements should be received well in advance of registration, since it takes at least three weeks for completion of arrangements.

STUDENT EMPLOYMENT — Many students depend upon part-time employment to help meet their expenses. Students who are thus employed, however, must recognize the time demands of their work schedules and will be required to adjust their academic loads accordingly. The Office of Student Employment, 105 Boucke Building, offers assistance in finding part-time employment in town, as well as on campus. This office also provides the student with assistance in finding summer employment. The Office of Student Aid coordinates the Federal College Work Study program, described above under Loan and Employment Programs.

The State College Area Chamber of Commerce also gives assistance to students seeking part-time employment. The Chamber of Commerce, local placement services, and the University Office of Personnel maintain files of positions open to spouses of students. Many local residents seek help for babysitting, housework, typing, and other general kinds of employment.

A student holding a fellowship or traineeship may not accept employment of any kind for service without special advance approval. A graduate assistant may accept concurrent employment outside the University only after obtaining permission from the department head and person in charge of the major program. Concurrent appointments with the University other than a Fellowship Supplement normally may not be held.

VETERANS' BENEFITS — The Coordinator of Veterans Affairs has the responsibility of handling all applications for benefits under the various Public Laws. Veterans who intend to enroll at the University should contact the Veterans Outreach Office, 335 Boucke Building, University Park, PA 16802, as far in advance as possible to obtain information and necessary forms. The Outreach Office also provides information on other programs and services unique to veterans.

Under P.L. 89-358, a student is entitled to benefits if registered full time for 8 or more credits, unless the department head certifies that fewer credits constitute a full-time academic load for that student (see Full-Time Academic Status, p. 68).

At each registration, a special veterans (V) card must be submitted to confirm enrollment and academic status. Submission of this card does not generate benefits which are not already certified, but failure to submit the card results in immediate interruption of VA benefits.

Veterans in their first term may defer tuition and room and board fees until their benefit checks begin to arrive.

Federal law and Veterans Administration Regulations specify the conditions under which veteran students and eligible dependents are paid VA educational benefits. Veterans Administration benefits are paid under the standards of academic progress and policies relating to student conduct contained in this bulletin and which apply to all graduate students. In addition, certain special conditions for payment of VA educational benefits must be met:

1. Courses which do not meet graduation requirements in the student's approved major (the major which the student has declared to the VA) cannot be computed as part of the student's course load for payment of VA benefits.
2. Unless mitigating circumstances exist, VA benefits cannot be paid for attendance of any portion of a course or term that is not completed.
3. Regardless of academic standing, any veteran student or eligible dependent who fails, or records a combination of failures and withdrawals, in all courses attempted during a term must be reported to the Veterans Administration for lack of satisfactory progress.
4. Unless *specific documentation* of an identifiable professional or academic goal can be provided (e.g., teachers requiring 24 graduate credits to obtain permanent certification), no veteran or eligible dependent may be certified for payment of VA educational benefits for any term subsequent to one during which he or she accumulates 12 credits on a nondegree status.
5. Since a 3.0 cumulative grade-point average is required for graduation, graduate student veterans and eligible dependents will be warned that their VA educational benefits may be suspended if their cumulative grade-point average falls below 3.0 during any given term. If the student's average remains below 3.0 for a second consecutive term, the VA Certifying Official will request a determination of whether progress has been satisfactory from the appropriate department head. If it has not, the VA Certifying Official will suspend benefits and report the veteran to the VA for lack of satisfactory progress.
6. Veterans and eligible dependents must report any change in academic status (change of credit load, change of major, etc.) to the Office of Veterans Affairs or other appropriate VA Certifying Official promptly and personally.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth here in the *Graduate Degree Programs* catalog and in the *Thesis Information Bulletin*, and for meeting the standards and requirements expressed by these regulations. Copies of the graduate catalog are available from the Graduate Commons Information Desk, 113 Kern Graduate Building; the *Thesis Information Bulletin* can be obtained from the Office of Theses and Publications, 320 Kern Graduate Building. Graduate students are encouraged to contact the Office of Graduate Student Programs, 211 Kern Graduate Building (Tel. 865-1834), for guidance if they have any questions, uncertainties, or difficulties concerning any procedure or regulation of the Graduate School or any procedure or regulation of the University as it may affect them.

STATEMENT OF NONDISCRIMINATION

The Pennsylvania State University, in compliance with applicable federal and state equal opportunity laws and regulations governing affirmative action and nondiscrimination, does not discriminate in the recruitment, admission, and employment of students, faculty, and staff in the operation of any of its educational programs and activities as defined by law. Accordingly, nothing in this publication should be viewed as directly or indirectly expressing any limitation, specification, or discrimination as to race, religion, color, or national origin; or to handicap, age, sex, or status as a disabled or Vietnam-era veteran, except as provided by law. Any inquiries concerning this policy may be directed to the Affirmative Action Officer or to the Vice President for Student Affairs.

ADMISSION

Each step of the educational process, from admission through graduation, requires continuing review and appropriate approval by University officials. The University, therefore, reserves the right to change the requirements and regulations contained in this bulletin and to determine whether a student has satisfactorily met its requirements for admission or graduation, and to reject any applicant for admission for any reason the University determines to be material to the applicant's qualification to pursue higher education.

An applicant for admission to the Graduate School should understand that graduate work is not a simple extension of an undergraduate program but, rather, demands scholarship of a higher order, and emphasizes research, creativity, and professional competence with a minimum of formal requirements and a maximum of student initiative and responsibility.

Objective — The objective of the Graduate School is to admit a qualified graduate student body up to the limit of the University's resources to provide outstanding graduate programs. In general, a student may begin graduate work in fall, winter, spring, or summer.

Applicants must recognize that staff, facilities, and other resources are limited, so that not all qualified persons can be admitted. The number accepted will vary by program, and from term to term. In some graduate programs all vacancies will have been filled long before the general Graduate School deadline for submitting applications, so that even outstanding students cannot be accepted.

Application — Applicants interested in graduate programs offered at University Park or The Milton S. Hershey Medical Center should apply to University Park. Those interested in programs at the Capitol Campus, the Radnor Center for Graduate Studies, or Behrend College should apply directly to the appropriate campus. Students are normally expected to begin work at the campus to which they are admitted.

Qualifications — For admission to the Graduate School, an applicant must have received from an accredited institution, a baccalaureate degree earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. Ordinarily, an entering student must have completed in a satisfactory manner a minimum of course work in designated areas, the specific courses and amount of work depending upon the field of advanced study. All applicants must submit Graduate Record Examination Aptitude Test scores. Individual graduate programs and departments may require Advanced Test scores.

A baccalaureate degree holder with a slight deficiency in undergraduate preparation may be admitted and allowed to schedule a limited number of undergraduate courses to remove the deficiency while proceeding in the graduate program. Courses taken for this purpose do not apply toward the requirements of the advanced degree.

Admission may be granted to applicants whose credentials are not complete at the time of application because the baccalaureate degree has not yet been conferred, grades for the current term are not yet available, GRE scores have not yet been reported, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission should, for any reason, be canceled, the student is thereby automatically dropped from the Graduate School.

Admission is granted jointly by the Graduate School and the department or graduate program in which the student plans to study. The establishment of standards by which applicants are admitted is a departmental or program responsibility. Although the Graduate School has no fixed minimum grade-point requirement for admission, an applicant is generally expected to maintain a junior-senior grade-point average of at least 2.50 on The Pennsylvania State University grading scale of A (4) to D (1). Individual programs may establish higher grade-point average requirements and use other criteria to judge candidates for admission. In exceptional cases, departments or major programs may also approve admission by reason of special backgrounds, abilities, and interests. Departmental or program requirements are given in the descriptive statements appearing under the major programs listed in the latter part of this publication.

A student who has been admitted to a program in which the doctorate is offered may begin working toward that degree but has no official status as a doctoral student and no assurance of acceptance as a doctoral candidate until a candidacy examination administered by the major department or committee has been passed.

Forms — Application forms may be obtained from the Office of Graduate Admissions. Applicants may apply for admission to only one program at a time. All academic records, including an explanation of the grading system used, should be submitted, *in duplicate*, to the Office of Graduate Admissions, 201 Kern Graduate Building. These must be received from all institutions by the Graduate School at least one month prior to the opening of the term in which the student plans to begin a graduate program.

Deadlines — The deadline for processing of applications by the Graduate School is one month prior to the beginning of any given term. GRADUATE MAJOR PROGRAMS MAY REQUIRE EARLIER DEADLINES. A complete Graduate School admissions file, which is required for processing an application, includes the following items: (1) application form, (2) application fee form, (3) a check or money order in the amount of \$20.00 made payable to The Pennsylvania State University, and (4) duplicate transcripts from each institution of higher education attended. Supplementary materials and examination scores may be required in individual programs. If the admission file is incomplete a month prior to the beginning of the term for which the student has applied, the materials will be processed for the first term following the completion of the admissions file.

Nondegree — A student who plans to take courses for transfer to another institution or to follow a program of study not leading to an advanced degree at this institution should apply for admission as a nondegree student. The adviser for such a student may be appointed by the department head or program chairman most closely associated with the student's field of interest. The number of nondegree students which can be admitted is limited because preference is given to students in degree programs.

Minority Students — Minority students are encouraged to apply for admission to any of the programs offered in the Graduate School. Information concerning programs and financial aid may be obtained from the chairman of the graduate program or the dean of the college of the student's major interest.

International Students — International students should plan to apply at least six months prior to the beginning of the term in which they intend to begin graduate studies. They must submit, *in duplicate*, certified English translations of all academic records. In addition, all international students whose native language is not English must take the TOEFL (Test of English as a Foreign Language) and submit the results of this test with the application for admission. A student must present a minimum TOEFL score of 525 to enter the competition for admission. Students who score 550 or above on the TOEFL will have satisfied the Graduate School's English language proficiency requirement for international students. Information about the TOEFL can be obtained by writing to the Educational Testing Service, Box 592, Princeton, NJ 08540. International students are not admitted as nondegree students unless such admission is requested by a sponsoring agency. Nondegree students must also fulfill the Graduate School English language proficiency requirement.

ENGLISH PROFICIENCY OF INTERNATIONAL STUDENTS — Entering graduate students whose native language is not English are required to demonstrate high-level competence in the use of the English language, including reading, writing, speaking, and listening. International students who have been admitted to graduate study with TOEFL scores of 550 or higher will be considered to have met the Graduate School's English language proficiency requirement. International students who have been admitted with TOEFL scores below 550 will be scheduled for diagnostic testing and assigned appropriate remedial work to improve their English language proficiency. Such students will demonstrate that they meet the established English language proficiency requirement by retaking the TOEFL and achieving a score of at least 550. Under ordinary circumstances, it is expected that the master's candidate will demonstrate proficiency during the first or second term of graduate study. Doctoral candidates who have been admitted with TOEFL scores below 550 must retake the TOEFL and achieve a score of at least 550 before they are admitted to candidacy for the degree.

UNDERGRADUATE STUDENTS — A student of The Pennsylvania State University who is within three credits of completing the baccalaureate degree may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade-point average of 3.00). Any senior with a 3.50 grade-point average may be admitted to 500-level courses with the consent of the instructor; other students of at least tenth-term standing with a B average or better may be admitted to such courses with the consent of the instructor, the student's academic adviser, and the associate dean of the Office of Graduate Student Programs.

In certain cases undergraduate students may subsequently apply credits they have earned in 400- and

500-series courses toward an advanced degree at The Pennsylvania State University. Upon admission to the Graduate School, and with the approval of the major field, those credits *relevant* to the graduate program of study which were not used to satisfy undergraduate requirements may be applied toward an advanced degree. The time limitation on the completion of a master's degree program applies to these, as well as to other, credits.

GUESTS OF THE UNIVERSITY — It is the policy of the Graduate School not to permit applicants to work for a second doctoral degree. The President, on recommendation of the dean of the Graduate School, will welcome, as guests, holders of earned doctoral degrees who may be visiting the University Park Campus for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the dean of the Graduate School.

STUDENT PENNSYLVANIA RESIDENT STATUS — When it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that the applicant is a non-Pennsylvanian. If a student who is thus admitted believes that the circumstances do not justify classification as a non-Pennsylvanian, a written petition for reclassification may be filed with the Financial Officer of the Graduate School, 316 Kern Graduate Building, University Park, PA 16802. Capitol Campus students may petition the Capitol Campus Financial Officer.

A copy of the *Policy for Determination of Students' Pennsylvania Resident Status* can be obtained in the Office of the Financial Officer mentioned above. Under the rules of this document, when a written petition for reclassification is made, the petitioner is required to present proof of bona fide domicile within the Commonwealth or such other evidence as is pertinent to a complete review of the student's classification. Upon review, a decision by the highest designated authority at the University shall constitute an exhaustion of administrative remedies.

Any reclassification resulting from a student's challenge shall be effective for tuition purposes as of the date such challenge was filed. A student who changes domicile from Pennsylvania to another state must promptly give written notice to the University.

CLASSIFICATION OF STUDENTS

A graduate student may be admitted either as a degree student or as a nondegree student, depending upon the student's objectives. After admission to one of these categories, any change to the other must be arranged through the Office of Graduate Student Programs.

DEGREE STUDENTS — A degree student is one who plans to become a candidate for an advanced degree at The Pennsylvania State University and who has been formally admitted for advanced studies in a particular program. The program of study is developed under the guidance of an adviser appointed by the head of the student's major program. A degree student who has passed a candidacy examination is classified as a doctoral candidate.

NONDEGREE STUDENTS — An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced degree at this institution, may arrange for a program of work as a nondegree student. This classification includes students who plan to transfer credits to another institution and those who plan special programs of study not leading to an advanced degree. The number of nondegree students who can be admitted is limited, and it is increasingly difficult to provide for them because of the limitation of resources. Preference is given to students in degree programs.

Nondegree students who are applying for admission to the University Park Campus *must* submit two transcripts from each institution attended. Transcripts should be sent to the Office of Graduate Admissions, 201 Kern Graduate Building, The Pennsylvania State University, University Park, PA 16802.

The admission of a nondegree graduate student at the University Park Campus will be subject to the recommendation of the program chairman or head of the department of the student's primary interest and proposed area of work. Casual students with broad interests not easily identifiable with a single program may be admitted directly by the Graduate School. Applications and credentials must be received at least one month prior to the anticipated term of enrollment. A maximum of 12 credits earned as a nondegree student may be applied to a degree program.

UNDERGRADUATE NONDEGREE STUDENTS — Such a student is not a graduate student since a baccalaureate degree has not been earned. The student may not register for graduate courses or research (500 and 600 series) without permission from the Office of Graduate Student Programs. A student having attained junior standing in college may register for 400-level courses and is admitted through undergraduate admissions.

PROGRAMS

MAJOR PROGRAM — A student's major program is the field of primary interest and the one in which the greater portion of graduate work is taken. Programs are designed to prepare students to assume positions of informed and responsible authority in their fields and to contribute creatively to them. They promote not only specialization, but also breadth of scholarship, the ability to study and think independently, and familiarity with the principal techniques and important literature in the field. The research undertaken by the candidate should deal with a problem which represents a significant contribution to knowledge.

SPECIAL INTERDISCIPLINARY MAJORS — In addition to the graduate major programs listed in this bulletin on pages 84-85, special interdisciplinary majors involving two or more departments within a single college, or intercollege majors involving two or more colleges, may be arranged with the approval of the dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental or intercollege committees.

In general, departments of the University are identified with specific major programs. Thus, aerospace engineering is a major program of study which is offered under the supervision of the Department of Aerospace Engineering. On the other hand, acoustics and genetics are major programs for which there are no corresponding departments. In such cases, a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one program. For instance, the Department of Material Sciences offers work in ceramic science, fuel science, metallurgy, and mineral processing.

Applicants for admission are encouraged to consult the person whose name is listed under the major program heading in the Programs and Courses section.

ADVANCED DEGREES OFFERED

The degrees of Doctor of Philosophy and Doctor of Education are conferred by the University. Both require high attainment and productive scholarship, but the Ph.D. places a strong emphasis on research, whereas the D.Ed. emphasizes professional competence in some field of education.

The Master of Arts and the Master of Science degrees are academic in nature, the programs placing strong emphasis on basic knowledge and research. The professional master's degrees conferred are the Master of Administration, Master of Agriculture, Master of Architecture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forest Resources, Master of Music, Master of Psychosocial Science, Master of Public Administration, and Master of Regional Planning.

Candidates for the M.Adm., M.P.A., M.Ps.Sc., or M.R.P. degrees may meet all the requirements for these degrees at the Capitol Campus of The Pennsylvania State University. Programs leading to the degree of Master of Engineering with a major in engineering science have been approved for Behrend College, the Radnor Center for Graduate Studies, and the Capitol Campus. The M.P.A. program also is available at the Radnor Center. Designation of location of program completion will be noted on the student's transcript.

CHANGE OF DEGREE OR PROGRAM

A graduate student who has been admitted for work in one major program but wishes to transfer to another should submit a request to the Office of Graduate Student Programs of the Graduate School. The student's credentials will be reviewed and the proposed new major department head or committee chairman consulted. If the change is approved but the student is inadequately prepared for the new major, the student may be required to make up certain undergraduate deficiencies.

A graduate student admitted for either an academic degree (M.A., M.S., or Ph.D.) or a professional degree (M.Adm., M.Agr., M.Arch., M.B.A., M.E.P.C., M.Ed., M.Eng., M.F.A., M.F.R.,

M.Mus., M.P.A., M.Ps.Sc., M.R.P., or D.Ed.) who wishes to change from one type of degree program to another must apply to the Office of Graduate Student Programs for the transfer. Similarly, a student who has earned a master's degree but wishes to earn a different type of doctoral degree must apply for a formal transfer. A student may be required to make up certain deficiencies if inadequately prepared for the new program.

GRADUATE CREDITS

It is important that the student understand that in the Graduate School the word "credit" has no meaning other than as a unit of time — time spent in residence and in off-campus graduate work. One credit stands for the equivalent of approximately one week of full-time graduate work, and 10 credits for a term's work.

Typically, a candidate for an advanced degree is required to earn a certain minimum number of credits at The Pennsylvania State University. Consequently, there is a limit to the number of credits which may be earned at another approved institution or through continuing education to meet the minimum requirements of the degree. Moreover, the department or committee in charge of a major program may require a student to do more of the work at the University than specified by the limitations set by the Graduate Faculty. The normal credit load of a full-time graduate student is 8 to 10 credits per term, or the equivalent (see Academic Credit and Employment, page 67).

Graduate courses carry numbers from 500 to 599. Advanced undergraduate courses numbered between 400 and 499 may be used to meet some graduate degree requirements when taken by graduate students.

CONTINUING EDUCATION — A large number of courses carrying credit are given throughout the Commonwealth of Pennsylvania through continuing education. All 400-series courses so offered *may* be used to meet graduate degree requirements when taken by students who have been admitted to the Graduate School. The graduate adviser's signature is required on the official registration form, which the student submits at the designated place of registration for the course.

There is no limit to the number of credits which a student may earn in continuing education, but not more than 10 credits in 400-level courses so earned may be applied toward the minimum requirements for an advanced degree.

REGISTRATION

The responsibility for being properly registered rests with the student. The student is expected to register each term, for either course work or research toward the thesis, whether it be on or off campus. In the case of research, the number of credits shall be determined by the amount of time required for the investigation, one credit representing the equivalent of one week of full-time work. In the later stages of the program the situation will determine the requirements for the student's registration. (See below, **REGISTRATION NEAR THE COMPLETION OF A PROGRAM**.)

ADVISERS — To assist the student in planning a program, the head of the major department or program chairman will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of an adviser from the department head and to seek a conference before registration.

TIME OF REGISTRATION — Registration days are indicated in the calendar at the beginning of this catalog.

A student is expected to complete registration during the officially designated period and to attend the first meeting of all classes. If this is impossible because of some emergency or unusual circumstance, the student may be granted permission by the instructor to miss a few class meetings, it being understood that work missed will be made up subsequently. Under these conditions permission may be granted through the Office of Graduate Student Programs for the student to register late. In general, a student who receives permission to register late will be required to reduce the course load in proportion to the length of the absence.

A student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge, regardless of when the student begins attending classes.

CONTINUITY OF REGISTRATION — A student who registers at University Park without interruption for each of the three terms in the September-to-June interval, for all four terms each year, or for summer terms only is considered to have maintained a normal continuity of registration.

Anyone who has interrupted such a normal sequence and now plans to register for work at the University Park Campus is required to apply to the Office of Graduate Student Programs, 211 Kern Graduate Building, at least one month before the time of registration, for permission to resume study.

The policy may be summarized for any specific term as follows:

Summer Term — Application required unless the student was registered at University Park for the preceding spring term or the preceding summer term.

Fall Term — Application required unless the student was registered at University Park for the preceding summer term or the preceding spring term.

Winter Term — Application required unless the student was registered at University Park for the preceding fall term.

Spring Term — Application required unless the student was registered at University Park for the preceding winter term.

PROCEDURE — For each registration the student, in consultation with the adviser, prepares a schedule of courses and research designed to fit individual needs. The credit load will be reviewed at the time of registration. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned for work done away from the campus. A student contemplating such work should inquire at the Office of Graduate Student Programs about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed before the close of central registration at University Park.

A student must register for courses audited as well as for those taken for credit.

REGISTRATION NEAR THE COMPLETION OF A PROGRAM — A candidate for the Ph.D. degree is required to register continuously (at least three terms of each four) from the time the comprehensive examination is passed and the three-term residence requirement is met until the thesis is accepted by the doctoral committee, regardless of whether work is being done on the thesis during this interval.

D.Ed. degree candidates and master's students may be required to register for a normal credit load because of their appointment status. If not, and if they have earned more than 90 (D.Ed.) or 30 (master's) credits and have met the requirements for their degrees except for the completion of the thesis, these students may register for as few as two credits per term. A student, other than the Ph.D. degree candidate, who has met the minimum requirements for a degree and is now completing research and thesis writing off campus is not required to register, even if visits are made to the campus several times each term to see an adviser, unless required to do so within the program.

A student, other than one following the Ph.D. requirement, is not required to register for the final term in order to graduate or in order to make minor revision to the thesis and/or to take a final examination for the degree, unless required to do so by the program.

VISITING AND AUDITING CLASSES — A graduate student registered for a given term who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during that term.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership, such as participating in discussion, doing practicum work, or taking examinations. Registration is not required for the privilege of visiting, and no record appears on the student's transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally enjoy the privileges of a class member. Registration procedures and fee payment are the same as for taking the course for credit. No credit is given, either on completion of the course or at a later time; however, the number of credits assigned to the course appears on the grade report and on the student's transcript. Thus, when a student receives an audit grade, the number of credits audited is shown. The symbol Au shall be used if attendance has been regular, the symbol W if attendance has been unsatisfactory.

A graduate assistant or fellow, who is required to register for a certain minimum number of credits, is not permitted to count audited course credits toward the minimum credits needed. The 1G and 2G language courses are an exception. The student may register for credit or audit beyond the required minimum but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for a course as auditors. However, visiting is not permitted in German 1G and 2G.

In the 1G and 2G courses offered by the language departments, no distinction is made between registering for credit and for audit in considering loads.

THESIS RESEARCH — In registering for thesis research a student uses the appropriate number (600, 610) preceded by the abbreviation designating the major field. The numbers 600 (on campus) and 610 (off campus) are available for credit in thesis research in all graduate major programs.

THESIS PREPARATION — The numbers 601 and 611 are available to Ph.D. degree candidates and are used for special noncredit registration for thesis preparation work. Such candidates must have passed the comprehensive examination and must have met the three-term residence requirement. A candidate registered for SUBJ. 601 is classified as a full-time student, while one registered for SUBJ. 611 is classified as a part-time student.

The numbers 600, 601, 610, and 611 may not always appear in the *Schedule of Classes* for each term.

COMMON COURSES — The following courses for which students may register have been set up for common use by major programs, with University Senate approval, to encourage innovation and provide flexibility in designing graduate programs:

590. **COLLOQUIUM (1-3)** Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.

596. **INDIVIDUAL STUDIES (1-6)** Creative projects, including nonthesis research, which are supervised on an individual basis and which fall outside the scope of formal courses. A specific title may be used in each instance and will be entered on the student's transcript. Multiple offerings may be accommodated by the use of suffixes a, b, etc.

597. **SPECIAL TOPICS (1-6)** Formal courses given on a topical or special interest subject which may be offered infrequently; several different topics may be taught in one year or term. A specific title may be used in each instance and will be entered on the student's transcript. Multiple offerings may be accommodated by the use of suffixes a, b, etc.

602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)** May be offered by any graduate program in a department which also offers undergraduate courses. A graduate program with no counterpart undergraduate program may offer SUBJ. 602 when cooperative arrangements are made with an administrative unit which does not offer graduate degrees but which uses graduate assistants in its teaching. SUBJ. 602 may be offered in any term and is subject to the following restrictions:

1. SUBJ. 602 shall not be counted in fulfilling any specific credit requirement for an advanced degree.
2. SUBJ. 602 shall be graded (A, B, C, D, F).
3. SUBJ. 602 shall not be used in calculating grade-point averages.
4. SUBJ. 602 shall be offered only in those graduate programs wishing to provide opportunity for supervised and graded teaching experience. Enrollment shall be restricted to students for whom the major program is prepared to provide such experience.
5. SUBJ. 602 may, but need not, be counted as a part of the normal credit load for graduate assistants.

ACADEMIC CREDIT AND EMPLOYMENT

To provide flexibility in arranging credit loads for graduate assistants and full-time University staff members, a procedure has been set up whereby the normal credit limits may be changed by permission of the person to whom the student or staff member is responsible for University employment or assistantship assignment. Maintenance of the established credit loads and responsibility for the conse-

quences of a graduate student's change of course load rests with the student and adviser. The course load is a factor in determining whether a graduate student is classified as a full-time or part-time student; has met residence requirements; and is eligible to hold a fellowship, scholarship, assistantship, or departmental or program appointment. Students holding fellowships, traineeships, or other awards based on academic excellence are commonly required to carry 8 or more credits each term.

The University takes the position that the facilities of the Graduate School should be made available first to students who can profit from their graduate school experience to the maximum extent. More than doing what is required in courses or in research, the graduate experience is one of living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in discussions, both formal and informal, with faculty members and fellow students. It is an involvement and participation in student affairs, University and Graduate School governance, committee assignments, and personal contribution of effort to the welfare and betterment of the University graduate community. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of, one's specialty. Students who propose schedules of few credits not requiring serious effort, or those who wish to carry overloads of such proportion as to handicap them seriously in achieving maximum quality, find it difficult and often impossible to experience the satisfaction of a well-rounded scholarly attainment.

A graduate student should achieve a balance between academic credit load, employment, and appointment responsibilities which results in classification as a full-time graduate student with all the privileges and responsibilities intrinsic to this classification. The student's full-time classification is certified by the department head or program chairman and is sent to the Office of Graduate Student Programs.*

FULL-TIME ACADEMIC STATUS — In establishing credit loads, a student who in any term is registered for 8 or more credits *or* who holds a quarter-time assistantship and schedules 7 credits *or* who has a half-time assistantship and schedules 5-7 credits is considered to be engaged in full-time academic work for that term.

PART-TIME ACADEMIC STATUS — A student who in any term is registered for fewer than 8 credits and does not hold a half-time or quarter-time assistantship is considered to be engaged in part-time academic work for that term.

FULL-TIME EMPLOYMENT OFF CAMPUS — A candidate for the Ph.D. degree may not count the work of any term toward the residence requirement for this degree while engaged in full-time employment off campus.

BENEFITS AND PRIVILEGES — A student registered for 6 or more credits of course work *or* for noncredit SUBJ. 601 *or* who holds a half-time assistantship and is carrying at least 5 credits is entitled to the *nonacademic* student benefits and privileges of a full-time student.

STAFF EMPLOYEE CREDIT STATUS* — A full-time staff employee of the University may schedule 4 credits per term (up to 16 credits per academic year), either for credit or audit.

No member of the faculty in one of the professorial ranks in the University may receive the master's degree or the doctoral degree from the University.

For University staff employees desiring to take graduate degree work, admission to the Graduate School is a first essential.

EMPLOYMENT — Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, whether on campus or off campus, must recognize the time demands of a work schedule in planning an academic program. A student holding a fellowship or scholarship may not accept employment of any kind for service beyond that specifically permitted by the appointment. Graduate assistants may accept concurrent employment outside the University only after obtaining permission from the head of the department providing the assistantship and from the person in

*Full-time University employees and three-quarter-time graduate assistants may meet Ph.D. degree residence requirements by registering for the full number of credits allowable (4 credits per term for full-time University employees, 4-5 credits for three-quarter-time assistants) and by obtaining certification from the department head as being principally engaged in activities relating to their academic programs.

charge of the assistant's graduate program. A graduate assistant may not hold a concurrent appointment with the University other than a Fellowship Supplement.

COURSE-NUMBERING SYSTEM — Courses in the series 1-399 are not listed in this catalog because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclass students with at least junior standing and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 77-83 under the specific requirements for the various master's degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.50, and other students who have been granted permission to enroll through the Office of Graduate Student Programs.

The numbers 600 (on campus) and 610 (off campus) are available for credit in thesis research in all graduate major programs. The numbers 601 and 611 do not denote courses but are used for noncredit special registration for thesis preparation by a Ph.D. candidate. Registration under these numbers will maintain status as a student during the interval which begins at the time the student passes the comprehensive examination and meets the three-term residence requirement and ends at the time the doctoral committee accepts the thesis. The student will register for 601 if engaged full time in the preparation of a thesis, or will register for 611 if engaged only part time in thesis preparation. Candidates for the Ph.D. degree do not receive grades for noncredit registrations (601 and 611).

SCHEDULE OF COURSES — A complete list of the courses which will be offered in any specific term is given in the *Schedule of Classes*, which is available at nominal cost from the Scheduling Office approximately four months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

The following grading system is in effect: Any one of five quality grades (A,B,C,D,F) may be given a graduate student for course work or for thesis research. The grade-point equivalents are 4, 3, 2, 1, 0, respectively.

At the 400, 500, and 600 levels, grades of A, B, and C denote graduate credit, whereas D and F are failing grades for graduate students, D being the normal failing grade. A grade of F indicates doubt in the judgment of the instructor of the student's potential for further graduate study.

A minimum grade-point average of 3.00 for work done at the University is required for graduation.

In addition to the quality grades listed above, two symbols, Def. (deferred) and R, may appear on a student's transcript. If work is incomplete at the end of a term for a reason beyond the student's control, or if very little work remains to be done, the instructor may report Def. in place of a grade, which will appear temporarily on the student's record. The deferral must be removed within six weeks of the beginning of the succeeding term, unless a special extension is granted by the associate dean of the Office of Graduate Student Programs. If the work is completed within the specified period of deferral, and the instructor does not report a passing grade, the Graduate Recorder automatically records a failing grade after duly notifying the department head or program chairman to that effect. No student may be approved for a degree while a grade deferral for a required course remains on the record. Deferred grade cards may be obtained from the Graduate Recorder, 112 Shields Building.

In the case of thesis work, either in progress or completed, and certain courses approved by the University Senate, the instructor may report the symbol R in place of a grade. This symbol indicates that the student has devoted an adequate amount of time to the work scheduled but gives no indication of its quality. When reported for thesis work, this symbol will not influence the grade-point average and remains on the student's transcript permanently if not converted to a quality grade (A, B, C, D, or F) within one term of its recording. Quality grades reported for a given term for thesis work will be included in the cumulative grade-point average. Quality grades reported for research will not apply to R's given for earlier registrations and will not denote the quality of an entire series of R's. It is expected that

an R grade for a course will be changed to a quality grade when the work for that course has been completed. Ordinarily, a quality grade will be reported no later than the end of the following term.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in a degree program will be dropped from the University. A cumulative grade-point average below 3.00 for any term or terms may be considered as evidence of failure to maintain satisfactory scholarship. Action may be initiated by the department or committee in charge of the graduate major or by the chairman of the student's doctoral committee.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of intention to graduate (by filing a diploma card) and to pay the thesis fee at the beginning of the term in which an advanced degree is expected to be received. If the student does not graduate, the diploma card must be reactivated during the actual term of graduation. Deadlines are given in the calendar found at the beginning of this bulletin.

A preliminary graduation list is prepared by the Graduate Recorder soon after the deadline for each term. Transcripts are prepared and checked in the offices of the Graduate School and the Recorder. The records of candidates who appear to have met requirements are forwarded to major and minor department heads or program chairmen for review and recommendation. The final list of approved candidates appears in the commencement program.

Only those transfer credits which have been accepted by the Graduate School and entered upon the student's transcript by the Recorder before the graduate list deadline will be considered in evaluating a student for graduation at the end of that particular term.

Attendance at commencement exercises is expected, but forms for permission to receive the degree in absentia are available in the Office of Graduate Student Programs in 211 Kern Graduate Building and in the Office of Graduate Records in 112 Shields Building. The form must be completed and filed with the Graduate Recorder by the date specified in the Graduate Calendar.

All degrees conferred are tentative until final grade reports have been received and all requirements fulfilled, even though the student's name may have appeared in the commencement program. A student's transcript or diploma, or both, may be withheld until any outstanding financial obligations to the University have been paid.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred by the University. Recognized as different in purpose, the two programs consequently have different requirements in certain respects.

ADMISSION

A student who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major program in which the doctorate is offered may begin working toward a doctoral degree. However, the student has no official status as a doctoral student and no assurance of acceptance as a doctoral candidate until the candidacy examination has been passed. This examination is administered by the major department or graduate program and is given early in the student's program.

It is the policy of the Graduate School not to permit applicants to work for a second doctoral degree. The President, on recommendation of the dean of the Graduate School, will welcome, as guests, holders of earned doctoral degrees who may be visiting the University Park Campus for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State

University or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the dean of the Graduate School.

GENERAL REQUIREMENTS

No specified number of courses completed or credits earned will assure attainment of the doctorate. The general requirements are based upon a period of residence, the writing of a satisfactory thesis, and the passing of a comprehensive and a final oral examination. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate in some major programs. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly, the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed. degree.

GRADE-POINT AVERAGE

A minimum grade-point average of 3.00 for work done at the University is required for admission to the comprehensive examination and for graduation.

TIME LIMITATION

A student is required to complete the program within seven years from the date of acceptance as a candidate.

OFF-CAMPUS AND TRANSFER CREDITS

Subject to the approval of the adviser and the head of the major department or program chairman, a student may register for research to be done away from the University Park Campus.

A maximum of 30 credits beyond the baccalaureate at an approved school not granting the doctorate in the student's major program may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. A maximum of two full academic years of work (60 credits) beyond the baccalaureate at a graduate school which grants the doctorate in the candidate's major program may be accepted here to apply toward doctoral degree requirements. Advanced standing is awarded for only one master's degree. Academic work to be so transferred must meet the following criteria: (1) It must have been completed within five years prior to the date of admission to the Graduate School of The Pennsylvania State University; (2) it must appear on a graduate transcript; (3) it must be of at least B quality; and (4) it must be deemed applicable to the student's program by the current academic adviser, approved in writing, and submitted to the Graduate School director of admissions.

The following caveat should be noted. Pass-fail grades are not transferable to an advanced degree program unless the "pass" can be substantiated by the former institution as having at least B quality.

A completed master's degree may be transferred to a doctoral program with no intervening time limitation.

ADVISERS AND DOCTORAL COMMITTEES

Following admittance to a degree program, the student should confer with the head of that major department or program concerning procedures and the appointment of an adviser. Arrangement and approval of the details of the student's term-by-term schedule is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major program for this specific duty.

General guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of four or more members of the Graduate Faculty. One member shall be from outside the candidate's major program. (For the D.Ed. doctoral committee, this committee member must be a faculty member in the candidate's minor field or general studies area — See MAJOR PROGRAM AND MINOR FIELD under D.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS.) This committee is ap-

pointed through the Office of Graduate Student Programs, upon recommendation of the head of the major program, after the student is admitted to candidacy. At the discretion of the associate dean, other members may be added to the committee. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. The chairman, with the following exception, must hold senior membership in the Graduate Faculty. An associate member may supervise the research for a doctoral candidate, and, with the approval of the associate dean of the Graduate School, may serve as chairman of a doctoral committee.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after the student's admission to candidacy. It will prepare, give, and evaluate the candidate's examinations, and supervise and approve the thesis. A favorable vote of at least two-thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether another examination may be taken.

The committee will also notify the associate dean when the candidate is ready to have the comprehensive and the final oral examinations scheduled and will report the results of these examinations to the Office of Graduate Student Programs.

COMMUNICATION AND FOREIGN LANGUAGE COMPETENCE

A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School or must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must meet any communication and foreign language requirements which have been established within the major program. The candidate should ascertain specific language requirements by contacting the professor in charge of the program, whose name appears with the program description under GRADUATE MAJOR PROGRAMS AND COURSES.

If a candidate is to be examined for knowledge of a foreign language other than French or Spanish, the intention to take the examination must be reported to the secretary of the language department by the end of the first week of classes for the term during which the examination is to be taken. This date is one week prior to the examination date. This written examination will be administered on dates announced for each term in the Graduate Calendar at the beginning of this catalog.

The Pennsylvania State University has been named by Educational Testing Service as a testing center for the administration of the written tests for students to be examined in French or Spanish. Students wishing to make application to take these tests should, at their earliest convenience, check with the Office of Examination Services, 207 Mitchell Building, University Park, PA 16802. A test fee of \$12 is payable at the time of application. Times and places of tests will be given when the test application is filed.

Candidates for the Doctor of Education degree may be required to demonstrate competence in foreign languages.

CANDIDACY EXAMINATION

The candidacy examination is administered by the Graduate Faculty in the graduate major program and should be taken early in the student's program. The nature of the examination varies with the program and may be the master's examination if so allowed. The decision to admit or not to admit a student to candidacy must be made by the Graduate Faculty or a designated committee of Graduate Faculty. For the Ph.D. student the examination may be given after at least 12 credits have been earned in graduate courses beyond the baccalaureate. The examination must be taken within three terms after having earned 24 credits.

For the D.Ed. student, the examination should be given when the student has earned a total of approximately 30 credits, including the master's program and work done elsewhere. A student transferring from another graduate school with 30 or more transfer credits must take the candidacy examination prior to earning more than 10 credits here.

COMPREHENSIVE EXAMINATION

When a candidate for the Ph.D. or D.Ed. degree has substantially completed the course work, a comprehensive examination covering the major program and minor field of study is required.

A candidate for the Ph.D. must have satisfied the communication and foreign language requirement before taking the examination.

All candidates are required to have a minimum grade-point average of 3.00 for work done at the University at the time the comprehensive examination is given.

The examination is officially scheduled and announced by the associate dean for graduate student programs upon recommendation of the doctoral committee. It is given and evaluated by the doctoral committee and may be *either written or oral, or both*. A favorable vote of at least two-thirds of the members of the committee is required for passing. In case of failure it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The results are reported to the Office of Graduate Student Programs and will be entered on the candidate's official record.

When a period of more than five years has elapsed between the passing of the comprehensive examination and the completion of the program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

FINAL ORAL EXAMINATION

The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the associate dean for graduate student programs, on the recommendation of the doctoral committee, to take a final examination. Normally the final oral examination may not be scheduled until at least three months have elapsed after the comprehensive examination was passed, although the associate dean may grant a waiver in the case of an outstanding student. The deadline for holding the examination is seven weeks before commencement. It is the responsibility of the doctoral candidate to provide a copy of the thesis to each member of the doctoral committee at least one week before the date of the scheduled examination.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the candidate's whole program of study without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two-thirds of the members of the committee is required for passing. The results of the examination are reported to the Office of Graduate Student Programs and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether another examination may be taken.

Ph.D. — ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation; (2) the preparation of a thesis involving independent research; and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

RESIDENCE REQUIREMENTS

There is no required minimum of credits or terms of study, but over some twelve-month period during the interval between admission to candidacy and completion of the Ph.D. program the candidate must spend at least three terms (which may include the term in which the candidacy examination is taken) as a registered full-time student engaged in academic work on the University Park Campus or at The Milton S. Hershey Medical Center. Full-time University employees must be certified by the department as

devoting half time or more to graduate studies and/or thesis research to meet the degree requirements (see Academic Credit and Employment, page 67).

CONTINUOUS REGISTRATION

After a student has passed the comprehensive examination *and* met the three-term residence requirement, no further registration for credit will be required by the Graduate School. However, status as a student must be maintained by registering continuously (at least three terms of each four, beginning with the first term after both of the requirements mentioned above have been met) until the thesis is accepted by the doctoral committee. This registration may be for (1) noncredit 601 or 611 only, with payment of the special thesis preparation fee; (2) noncredit 601 or 611 with payment of the special thesis preparation fee plus course registration at the regular per credit fee; or (3) full-time course credits with payment of the regular tuition fee. Grades are not given for noncredit 601 or 611. Failure to maintain registration will result in termination of student status.

MINOR FIELD

A Ph.D. candidate is not required by the Graduate Faculty to have a minor field of study. However, a department or a committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of the doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the master's degree, of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major program and the minor field.

THESIS

The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal an ability on the part of the candidate to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis must be submitted to the Office of Theses and Publications not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin*, which gives details concerning format, paper, typing, and other requirements, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building. Following editorial review of the thesis by this office, it is expected that the student will submit a copy of the thesis, incorporating format corrections, to the office of the department or program head.

D.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge and concurrence by the dean of the College, may also be offered in any other field appropriate to the preparation of teachers which has been approved for the doctorate.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles in classroom instruction, supervision of instruction, administration, or as a consulting specialist in certain educational areas; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successfully passing

examinations, i.e., showing a satisfactory grasp of the field of specialization and its relation to allied educational areas.

RESIDENCE REQUIREMENTS

A minimum of nine terms of full-time graduate study and research (10 credits per term), or their equivalent in credits (90 credits), of which at least 30 credits must be earned in residence, is required for the D.Ed. degree. The D.Ed. candidate may meet the requirements by attending summer terms unless the major department requires a period of registration in other terms or in consecutive terms at University Park. A candidate may register for a maximum of 30 credits of research in absentia, but none of these may count toward the minimum of 30 credits which must be earned at the University Park Campus. It is expected that students will register for a minimum of 15 credits of thesis research. The maximum credit load permitted a student who is employed full time is 4 credits per term.

MAJOR PROGRAM AND MINOR FIELD

The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major program of study.

A candidate choosing a major outside the field of education (such as speech, geography, or history) shall have a minor consisting of no fewer than 15 credits in education, including those applied toward the master's degree, as approved early in the major program by a faculty adviser designated by the College of Education.

A candidate choosing a major in one of the major programs in education must also choose either a minor or a group of general studies with the approval of the major program chairman. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside those of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields outside those of education considered by the major program committee to have significance and value for the candidate.

COMPREHENSIVE EXAMINATION

In addition to demonstrating a high level of competence in the subject matter in the major program and minor field, each candidate must show, by a comprehensive examination, an understanding of current theories of education and the ability to apply the techniques and findings of educational research so far as they bear upon the teaching of the subject matter. The candidate must also be able to understand and contribute to the technical and professional literature in the field, and to criticize learned procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include competence in the use of statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates are required to have a minimum grade-point average of 3.00 for work done at the University at the time the comprehensive examination is given.

THESIS

Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought, as well as ability and originality in the application of educational principles or in the development of new generalizations under scientific controls. A thesis may be based upon a product or project of a professional nature, provided scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis must be submitted to the Office of Theses and Publications not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

MASTERS' DEGREES

A *Thesis Information Bulletin*, which gives details concerning format, paper, typing, and other requirements, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building. Following editorial review of the thesis by this office, it is expected that the student will submit a copy of the thesis, incorporating format corrections, to the office of the department or program head.

MASTER'S DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees, academic and professional. Of the fifteen master's degrees conferred, the Master of Arts and Master of Science are academic in nature. The professional degrees conferred are Master of Administration, Master of Agriculture, Master of Architecture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forest Resources, Master of Music, Master of Psychosocial Science, Master of Public Administration, and Master of Regional Planning.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements as specified below under Additional Specific Requirements.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts the continuity of registration faces the possibility of not being granted permission to return.

GRADE-POINT AVERAGE

A minimum grade-point average of 3.00 for work done at the University is required for graduation.

TIME LIMITATION

All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

ADMISSION

In addition to the general University requirements for admission set forth at the beginning of this catalog, adequate undergraduate preparation is required in the program in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of program and can be ascertained from the descriptive statement appearing under the major program heading in the latter portion of this catalog. An applicant who meets the necessary grade-point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and be allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the necessary period of residence. An applicant for admission to the M.Ed. program in most major programs is required to have had at least 18 credits in education and related psychology, and in certain major programs may be required to have had practice teaching.

After admission to a degree program, a student should confer with the head of the major department or program concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major department or program in which the student is specializing. The adviser or the committee assists the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments or programs in addition to (but not in conflict with)

the regulations of the Graduate School. For details the student should consult the head of the major department or program.

TRANSFER CREDIT

Subject to the limitations given, a maximum of 10 credits of high-quality graduate work done at another institution may be applied toward the requirements for the master's degree. However, credits earned to complete a previous master's degree may not be applied to a second master's degree program at The Pennsylvania State University.

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program. Approval to apply any transferred credits toward a degree program must be granted by the student's academic adviser, and the adviser must notify the Graduate School director of admissions, in writing, when such approval is granted. Transferred academic work must have been completed within five years prior to the date of admission to the Graduate School of The Pennsylvania State University, must be of at least B quality, and must appear on a graduate transcript.

Pass-fail grades are not transferable to an advanced degree program unless the "Pass" can be substantiated by the former institution as having at least B quality.

Forms for transfer of credit may be obtained from the Office of Graduate Admissions, 201 Kern Graduate Building.

EXAMINATIONS

A candidate may be required to pass in a satisfactory manner written or oral examinations designated by the program head. A candidate should consult the major department or program for special requirements.

Examinations to establish credit for work done in absentia or without formal class work may be used to remove undergraduate deficiencies, but *not* to earn credits toward an advanced degree. Arrangements are made by the student directly with the major department head or program chairman.

Graduate Record Examinations are designed to test information and abilities in basic fields of knowledge. Provisions are made on the campus for administering these examinations at scheduled times and upon request of students or department program chairmen. Informational materials may be obtained at the Graduate School Information Center on the first floor of Kern Graduate Building.

M.A. and M.S. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred. Programs for both degrees are strongly oriented toward research.

A minimum of 30 graduate credits is required, of which at least 20 must be earned at an established graduate campus of the University. A minor is not required of all candidates for the M.A. or M.S. degree. A department or committee in charge of a major program may require a candidate to offer work in a minor field, or the minor may be elected with the permission of the student's committee.

A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major program and minor field.

The major department or the committee in charge of the major program is the judge as to the suitability of a field for the minor and of its relevance to the major. The minor field department has the responsibility of accepting or rejecting students, advising on courses to be taken by the candidate in the field, examining the candidate in the area of studies undertaken in the field, and certifying that the minor requirements have been met.

At least 18 credits in the 500 and 600 series, combined, must be included in the program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed

in the major program. A thesis is required of many candidates for these degrees. Details are given in the introductory paragraphs under the major program headings in the latter part of this catalog. If a student is required to write a thesis, at least 6 credits in thesis research (600 or 610) must be included in the program. If no thesis is required, at least 18 credits must be in 500-level courses.

A thesis is prepared under the direction of the department or program in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off campus. To do so, satisfactory arrangements must be made in advance with the adviser and the head of the major department or program.

Those candidates who are not required to write a thesis must present a suitable essay or paper. Its nature and extent shall be determined by the major program. The department head or program chairman shall report to the Office of Graduate Student Programs the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The program head may require one or more copies of the essay for the program's library or other files.

Some programs in the field of education offer the M.S. degree but prefer to admit students into the M.Ed. degree program. Other programs which emphasize research prefer to admit only students interested in pursuing the Ph.D. degree.

Requirements for the M.A. degree at the Capitol Campus differ somewhat from the above and are outlined under the major programs in American Studies and Humanities. These programs are available only at the Capitol Campus.

A *Thesis Information Bulletin*, which gives details concerning format, paper, typing, and other requirements, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building. Following editorial review of the thesis by this office, it is expected that the student will submit a copy of the thesis, incorporating format corrections, to the office of the department or program head.

M.Adm. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Administration degree program is offered only at the Capitol Campus. It is intended to meet the professional needs of practicing and potential administrators in the fields of business and engineering. Two options are offered: (1) the business administration option is intended for students who desire to pursue an administrative career in business, industry, or institutions; and (2) the engineering administration option prepares individuals for management positions in engineering, scientific, and technical organizations. Each student is required to complete a professional paper of the quality, if not the theoretical depth, of a thesis.

A description of the Administration program appears subsequently in this catalog. Further information can be obtained from the Capitol Campus.

M.Agr. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Agriculture is a professional degree. Programs leading to this degree provide opportunities for students to increase their knowledge and competences in the various phases of agriculture. A student, according to individual objectives, may obtain intensive training encompassing a wide spectrum of subject matter area or intensive training in a specialized area. The emphasis of the program is to enable students to develop skill as professional practitioners in the communication of technical knowledge and its application to the solution of current and future technical, economic, and social problems of individuals and groups.

The head of the department or program chairman shall appoint a three-member committee to guide and monitor the candidate's professional development. Members of this committee must represent at least two departments. The chairman of the appointed committee shall serve as the candidate's adviser. The candidate will inform the committee of personal aspirations and background early in the program. The committee will suggest to the student how best to achieve these goals and the standard of professional competence required for the Master of Agriculture degree.

A minimum of 30 graduate credits is required, of which 20 credits must be earned in residence at the University Park Campus. A maximum of 10 credits may be earned in special problem-type courses.

The candidate must present an acceptable paper on a selected professional problem or a report of internship training. Up to 3 graduate credits will be given for an acceptable paper. The candidate may be required to provide one or more copies of the paper for the University.

The candidate's committee shall report, through the department head or program chairman, to the Office of Graduate Student Programs the title of the paper and whether the paper and the candidate's academic performance were considered satisfactory.

M.Arch. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Architecture is a professional degree and is planned to provide the depth and breadth of knowledge needed to enter the architectural profession and become a licensed professional architect following the required period of internship. Admission requirements include the equivalent of 39 credits in design-research work and a statement of purpose concerning the professional aims of the candidate. The program is available to candidates holding a B.A. or B.S. degree with a major in architecture or environmental design, or holding other nonprofessional degrees in architecture.

A minimum of 60 graduate credits at 400/500 level is required, 36 of which must at the 500 level. A minimum of 30 credits must be taken at the University Park Campus. A thesis is optional. If a thesis is written, 6 credits of Arch. 600 must be completed. Professional areas of study include building design and architectural programming.

M.B.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The purpose of the Master of Business Administration degree program is to develop professional managerial knowledge and skills as these are applied to the decisions in complex organizations. Teaching focuses upon the techniques, the concepts, and the skills important to modern administrators.

A minimum of 48 graduate credits is required, all at the 500 level. Thirty-six credits must be in specified core courses. Also required are 12 credits in major field courses and electives (including a professional paper). Work for this degree may be started in the fall term only. Applications must include the results of the Graduate Management Admission Test.

M.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in education. They should be distinguished carefully from the research-oriented programs which lead to the academic degrees of Master of Arts or Master of Science. In most major programs the requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned at an established graduate campus of the University; at least 24 must be in course work. This degree is also offered at the Capitol Campus and the Radnor Center for Graduate Studies.

MAJOR PROGRAMS IN THE FIELDS OF EDUCATION

A student may major in one of the approved programs in education, such as curriculum and instruction, educational psychology, or home economics education, and proceed under the guidance of the appropriate major in education. At least 12 of the 24 credits in course work must be taken at the 500 level.

A program of this type requires at least 6 credits to be earned outside the programs in education, or the 6-credit requirement may be met with course work in the specific fields of educational psychology or cultural foundations of education.

MAJOR PROGRAMS OUTSIDE THE FIELDS OF EDUCATION

A student who is preparing to teach in a specific subject-matter field, such as economics, mathematics, or German, may choose such a program as a major and take a majority of work in it under the guidance of the department offering that major. A student wishing to study in a broader area may choose a major such as human development and family studies, earth sciences, or extension education and take at least 24 credits in the area under the guidance of the committee in charge of the major.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits may be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology.

THESIS OR PAPER

Six credits may be granted for an approved thesis. A candidate who does not elect to write a thesis is required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of this piece of writing, whether it be required in connection with a course or independent of course work, and when it is to be undertaken shall be determined by the major program. The department or division head or program chairman shall report to the Office of Graduate Student Programs the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the department or division head or program chairman to require one or more copies of the essay for the department's, division's, or program's library or other files.

M.Eng. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Engineering provide training for advanced professional competence in the several fields of engineering. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required, of which 20 must be earned at an established graduate campus of the University. At least 12 credits must be earned in graduate courses (500 series).

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

Work for this degree is not required to be done specifically on the University Park Campus. A complete program of study can be pursued at the Capitol Campus, at Behrend College, or at the Radnor Center for Graduate Studies of The Pennsylvania State University.

M.E.P.C. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Environmental Pollution Control is an intercollege professional degree designed for students who are interested in pursuing a career in the field of environmental pollution control. Special requirements include 9 credits of core courses covering air and water pollution control and solid waste management and participation in the environmental pollution control seminar program. A minimum of 30 graduate credits is required, of which at least 9 must be at the 500 level and 20 must be taken at the University Park Campus. A thesis is optional. If a thesis is written, at least 6 credits of thesis research (600 or 610) must be taken. Those who select the nonthesis option must submit a paper.

M.F.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Fine Arts provide training for increased professional competence in the several specialized areas of the arts. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts with a major in art or theatre arts.

A minimum of 48 credits is required, of which at least 38 must be earned at the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate in a particular field.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect of the program; the project and monograph shall represent a minimum of 6 credits on the 600 level.

M.F.R. — ADDITIONAL SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Forest Resources provides training for increased professional competence in the several specialized areas of forest resource management and forest products. It should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Science with a major in forest resources.

A minimum of 30 graduate credits is required, of which at least 20 must be earned at an established graduate campus of the University. At least 12 credits must be in courses at the 500 level, excluding F.P. 596, For. 596, and Wildl. 596.

A candidate for the degree of Master of Forest Resources may elect a minor with the permission of the committee. A minor consists of no fewer than 6 credits of integrated work in one field related to, but different from, that of the major. A minor program must meet the approval of the department or committee responsible for the minor field.

Each candidate is required to submit an acceptable paper which demonstrates an ability to apply to the professional field the knowledge gained during his or her program. Six to 9 graduate credits will be given for an acceptable paper, which may be completed off campus.

M.Mus. — ADDITIONAL SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Music provides training for increased professional competence in music. It should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Arts with a major in music history.

A minimum of 48 credits is required, of which at least 38 must be earned at the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect of the program; the project and monograph shall represent a minimum of 6 credits on the 600 level.

M.P.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration in local, state, and national governmental jurisdictions or in international, private, or voluntary agencies. The M.P.A. degree is offered at the University Park Campus, the Capitol Campus, and the Radnor Center for Graduate Studies.

The M.P.A. degree offered at University Park and Radnor requires a minimum of 30 graduate credits, of which 20 must be earned at the University Park or Radnor campuses. The greater portion of the courses must be at the 500 level. An M.P.A. essay or paper will also be required but will carry no graduate credit. A comprehensive final examination will be given to all candidates.

The M.P.A. degree offered at the Capitol Campus at Middletown requires a minimum of 45 graduate credits including a 9-credit field study (internship) experience and a professional master's project. The 9-credit field study requirement may be waived for students who have at least three years of full-time professional experience in relevant administrative or staff work. There is no comprehensive final examination, but an oral defense of the master's project report is required.

The program leading to the Master of Public Administration degree should be distinguished from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science, in which the candidate may specialize in public administration.

M.Ps.Sc. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Psychosocial Science degree, community psychology option, is a non-traditional program with an emphasis on practicum experience. The program is concerned with equipping students with some of the skills necessary to cope effectively with the multifaceted problems facing communities. Students should be able to recognize problems, to outline and implement possible solutions to these problems, and to evaluate the effectiveness of the solutions.

Forty-five graduate credits are required, 24 at the 500 level. A major portion of this degree is field work under the supervision of a faculty member. A paper is a necessary part of the practicum experience. An oral defense of the paper is required.

M.R.P. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Regional Planning is a professional degree for students interested in a multidisciplinary approach to the problems of regional and community development and resource management. The program provides the student with a solid background in planning theory and techniques, emphasizing planning within a multijurisdictional context in both urban and rural areas. The program provides flexibility for students to develop an area of specialization or to pursue a concurrent degree in a discipline related to planning.

For the M.R.P. degree at the University Park Campus, a minimum of 54 approved graduate credits is required, of which 36 must be earned at a graduate campus of the University. Six graduate credits will be earned in preparing (1) a thesis or (2) a professional paper comparable in quality and scope to a graduate thesis.

The M.R.P. degree at the Capitol Campus at Middletown requires a minimum of 45 graduate credits, 35 of which are required in planning courses, at least 6 of which will be earned in preparing (1) a problem-oriented thesis, or (2) an individual project report comparable in quality and scope to a graduate thesis, or (3) a project written in a terminal integrative course in regional planning.

GRADUATE MAJOR PROGRAMS OF STUDY

The following degrees are the ones normally conferred in each of the designated major programs. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head or program chairman and the dean of the Graduate School. For example, the M.Ed. has been authorized for all of the programs below in which a master's degree is conferred provided the program is appropriate to the preparation of teachers.

*Acoustics — Ph.D., M.S., M.Eng.
 Administration (Capitol) — M.Adm.
 Aerospace Engineering — Ph.D., M.S.
 Agricultural Economics — Ph.D., M.S.,
 M.Agr.
 Agricultural Education — Ph.D., D.Ed.,
 M.S., M.Ed.
 Agricultural Engineering — Ph.D., M.S.
 Agronomy — Ph.D., M.S., M.Agr.
 American Studies (Capitol) — M.A.
 Anatomy (Hershey) — Ph.D., M.S.
 Animal Industry — Ph.D., M.S., M.Agr.
 Animal Nutrition — Ph.D., M.S.
 Anthropology — Ph.D., M.A.
 Architectural Engineering — M.S.
 Architecture — M.S., M.Arch.
 Art — M.A., M.F.A.
 Art Education — Ph.D., D.Ed., M.S.,
 M.Ed.
 Art History — Ph.D., M.A.
 Astronomy — Ph.D., M.S.
 Biochemistry — Ph.D., M.S.
 *Bioengineering — Ph.D., M.S.
 Biological Chemistry (Hershey) —
 Ph.D., M.S.
 Biology — Ph.D., M.S.
 Biophysics — Ph.D., M.S.
 Botany — Ph.D., M.S.
 Business Administration — Ph.D., M.S.,
 M.B.A.
 Ceramic Science — Ph.D., M.S.
 Chemical Engineering — Ph.D., M.S.
 Chemistry — Ph.D., M.S.
 Civil Engineering — Ph.D., M.S.,
 M.Eng.
 Classics — M.A.
 Community Systems Planning and
 Development — Ph.D., M.S.
 Comparative Literature — Ph.D., M.A.
 Computer Science — Ph.D., M.S.
 Counselor Education — Ph.D., D.Ed.,
 M.S., M.Ed.

Curriculum and Instruction — Ph.D.,
 D.Ed., M.S., M.Ed.
 Dairy Science — Ph.D., M.S.
 Developmental and Remedial Reading —
 M.Ed.
 Earth Sciences — D.Ed., M.Ed.
 *Ecology — Ph.D., M.S.
 Economics — Ph.D., M.A., M.Ed.
 Education of Exceptional Children —
 Ph.D., D.Ed., M.S., M.Ed.
 Educational Administration — Ph.D.,
 D.Ed., M.S., M.Ed.
 Educational Psychology — Ph.D., M.S.
 Electrical Engineering — Ph.D., M.S.
 Engineering Mechanics — Ph.D., M.S.,
 M.Eng.
 Engineering Science — M.S.
 Engineering Science (Behrend, Radnor,
 Capitol) — M.Eng.
 English — Ph.D., D.Ed., M.A., M.Ed.
 Entomology — Ph.D., M.S., M.Agr.
 Environmental Engineering — M.S.,
 M.Eng., Ph.D.
 *Environmental Pollution Control — M.S.,
 M.Eng., M.E.P.C.
 Extension Education — M.Agr., M.Ed.
 Food Science — Ph.D., M.S.
 Forest Resources — Ph.D., M.S., M.Agr.,
 M.F.R.
 French — Ph.D., D.Ed., M.A.
 Fuel Science — Ph.D., M.S.
 *Genetics (U.P., Hershey) — Ph.D., M.S.
 **Geochemistry and Mineralogy —
 Ph.D., M.S.
 Geography — Ph.D., M.S.
 **Geology — Ph.D., M.S.
 **Geophysics — Ph.D., M.S.
 German — Ph.D., M.A., M.Ed.
 Higher Education — D.Ed., M.Ed.
 History — Ph.D., D.Ed., M.A., M.Ed.
 Home Economics Education — Ph.D.,
 D.Ed., M.S., M.Ed.
 Horticulture — Ph.D., M.S., M.Agr.

*Intercollege Graduate Program

**See Geosciences

Human Development and Family Studies — Ph.D., D.Ed., M.S., M.Ed.
 Humanities (Capitol) — M.A.
 Industrial Engineering — Ph.D., M.S., M.Eng. (Radnor, M.Eng.)
 Journalism — M.A.
 Laboratory Animal Medicine (Hershey) — M.S.
 Linguistics — Ph.D., M.A.
 Man-Environment Relations — Ph.D., D.Ed., M.S., M.Ed.
 Mathematics — Ph.D., D.Ed., M.A., M.Ed.
 Mathematics (Radnor) — M.Ed.
 Mechanical Engineering — Ph.D., M.S., M.Eng.
 Metallurgy — Ph.D., M.S.
 Meteorology — Ph.D., M.S.
 Microbiology — Ph.D., M.S.
 Microbiology (Hershey) — Ph.D., M.S.
 Mineral Economics — Ph.D., M.S.
 Mineral Engineering Management — M.Eng.
 Mineral Processing — Ph.D., M.S.
 Mining Engineering — Ph.D., M.S., M.Eng.
 Music — M.A., M.Mus.
 Music Education — D.Ed., M.Ed.
 Nuclear Engineering — Ph.D., M.S., M.Eng.
 Nursing — M.S.
 Nutrition — Ph.D., D.Ed., M.S., M.Ed.
 Nutrition in Public Health — M.S.
 †Operations Research — Ph.D., M.S.
 Petroleum and Natural Gas Engineering — Ph.D., M.S.
 Pharmacology (Hershey) — Ph.D., M.S.
 Philosophy — Ph.D., D.Ed., M.A., M.Ed.

Physical Education — Ph.D., D.Ed., M.S., M.Ed.
 Physics — Ph.D., D.Ed., M.S., M.Ed.
 *Physiology (U.P., Hershey) — Ph.D., M.S.
 Plant Pathology — Ph.D., M.S., M.Agr.
 Political Science — Ph.D., M.A.
 Poultry Science — M.S.
 Psychology — Ph.D., M.S.
 Psychosocial Science (Capitol) — M.Ps.Sc.
 Public Administration — M.P.A.
 Public Administration (Capitol) — M.P.A.
 Recreation and Parks — M.S., M.Ed.
 *Regional Planning — M.R.P.
 Religious Studies — Ph.D., M.A.
 Rural Sociology — Ph.D., M.S., M.Agr.
 *School Psychology — D.Ed., M.S., M.Ed.
 Slavic Languages and Literatures — M.A.
 Sociology — Ph.D., M.A.
 *Solid State Science — Ph.D., M.S.
 Spanish — Ph.D., D.Ed., M.A., M.Ed.
 Speech Communication — Ph.D., M.A.
 Speech Pathology and Audiology — Ph.D., D.Ed., M.S., M.Ed.
 Statistics — Ph.D., M.S., M.A.
 Teaching and Curriculum (Capitol) — M.Ed.
 Theatre Arts — M.A., M.F.A.
 Urban and Regional Planning (Capitol) — M.R.P.
 Veterinary Science — Ph.D., M.S.
 *Vocational Education — Ph.D., D.Ed.
 Vocational Industrial Education — Ph.D., D.Ed., M.S., M.Ed.
 Wildlife Management — M.S.
 Zoology — Ph.D., M.S.

*Intercollege Graduate Program

†Dual-title Program Option

GRADUATE MAJOR PROGRAMS AND COURSES*

ACOUSTICS (ACS)

JIRI TICHY, *Chairman of the Committee on Acoustics*
Applied Research Laboratory, Applied Science Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Ackerman, Baker, Brown, Brubaker, Fenlon, Hayek, Johnson, Lauchle, Martin, Michael, Neubert, Pigott, Reethof, Rowlands, Sibul, Skudrzyk, Snowdon, Thompson, and Tichy.

Graduate Faculty: Associate Members Andrews, Bienvenue, Farwell, Frost, Lawther, Macaluso, Maynard, O. H. McDaniel, S. T. McDaniel, Miller, Prout, Ricker, Stuart, and Wilson.

The aim of this intercollege program is to enable the student interested in acoustics to obtain an integrated program of courses covering the fundamentals of acoustical science and the biological, communications, and engineering applications of acoustics.

Programs are arranged through a selection of appropriate courses offered by several departments in the colleges of Science, Engineering, Education, and Arts and Architecture, as well as those specifically in the area of acoustics.

Areas of concentration include acoustic signal processing, architectural and building acoustics, noise and vibration, physical acoustics, speech and hearing, and underwater acoustics. Thesis research in the various areas may be conducted in relevant departments and in the Applied Research Laboratory.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by competence in the use of computer language, as well as a reading knowledge of a foreign language.

Entering students should hold a bachelor's degree in physics, biology, engineering, architecture, mathematics, psychology, speech and hearing, or in a closely related field; and they should have had at least one year of physics and mathematics including integral calculus. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

In addition to the acoustics courses listed below, the following courses on acoustics and closely related areas are available: Aersp. 412, 444, 506, 511, 515, 516, 517; A.E. 458, 542; E.E. 459, 560, 561, 562; E.Mch. 401, 412, 516, 521, 522, 524A,B, 525, 527, 528, 570; M.E. 458, 522; Phys. 443, 533; Sp.Com. 413, 431; S.P.A. 430, 434, 522, 531, 532, 534.

ACOUSTICS (ACS)

- 401. GENERAL ACOUSTICS (3)
- 402. FUNDAMENTALS OF ACOUSTICS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

*A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department or program offering the course.

A department or major program may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400- and 500-series courses an individual student may schedule fewer credits than the maximum number but in no case more than the maximum number authorized.

All courses listed under graduate major programs may not be required in the particular major.

511. UNDERWATER SOUND PROPAGATION (3) Theoretical and empirical treatment of sound propagation in the ocean, including effects of the environment, characteristics of targets, and transducers.
512. SONAR ENGINEERING (3) Theoretical and empirical treatment of problems related to the use of underwater sound in target detection and ranging.
513. MODERN ACOUSTIC SIGNAL PROCESSING (3) Probability review, representation of signals, noise processes, optimum filtering, ambiguity functions, linear and nonlinear signal processing, application to sonar systems.
514. ELECTROACOUSTIC TRANSDUCERS (3) The theory, design, and calibration of passive, linear, reciprocal electroacoustic transducers for use in both air and water media. Prerequisite: Phys. 443.
515. ACOUSTICS IN FLUID MEDIA (3) Wave propagation in stationary and moving fluids; acoustic radiation and scattering; standing waves in ducts and cavities. Prerequisites: E.Mch. 524A, Phys. 443.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

ADMINISTRATION (ADMIN)

ROBERT J. BROWN, *In Charge of the Graduate Program in Administration at Capitol Campus*
Middletown, PA 17057

Degree Conferred: M.Adm.

Graduate Faculty: Senior Members Dexter, Gilmore, and Murty.

Graduate Faculty: Associate Members Blumberg, R. Brown, T. Brown, Chisholm, G. Cole, DeRooy, Frey, McKenna, Murti, Poore, Redington, and Shaw.

This program is intended to meet the professional needs of practicing and potential administrators. Options are available in business administration and engineering administration. The business administration option is intended for those students who desire to pursue an administrative career in commerce, business, or industry. The engineering administration option is intended for students who wish to include courses in engineering and operations research as part of their program.

To obtain the degree three foundation courses must be satisfied, and a program of 33-47 credits must be completed. Research competence will be demonstrated by completion of the master's project. Students must register for Bus. 554 (Master's Project) for a total of 3 credits before, or at the same time as, they register for the last 6 credits of other course work.

For admission to the Master of Administration program, the student must have a baccalaureate degree from an accredited institution. Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

Applicants are required to take the Graduate Management Admissions Test.

The program is offered only at the Capitol Campus.

COURSES*

ADMIN. 486. APPLICATIONS OF STATISTICAL COMPUTER PACKAGES (1) Selection and application of computer packages for statistical analysis; construction and modification of files; design of program statements. Prerequisite: 3 credits in basic statistics.

ADMIN. 500. ADMINISTRATIVE THEORY (3) History, significance and functions of administration, theories of leadership, authority, decision making, rationality, and efficiency.

*Course descriptions not given below can be found under the designated field of study.

ADMIN. 505. PERSONNEL MANAGEMENT (3) Problems in effectively selecting, utilizing, and developing human resources from the viewpoint of the total organization — both private and public.

ADMIN. 510. ORGANIZATION BEHAVIOR (3) Examination of concepts of human behavior in formal organizations, systems analysis, conceptual models, and decision processes.

ADMIN. 515. LABOR MANAGEMENT RELATIONS (3) Labor relations issues; collective bargaining agreement, negotiations, and administration; legal framework of collective bargaining; labor relations in larger social context. Prerequisite: Admin. 500.

ADMIN. 520. ADMINISTRATIVE MODELS (3) Formulation and solution of decision models for administrative problems. Analysis of decision making under certainty, risk, and uncertainty. Prerequisites: Bus. 492, 493.

ADMIN. 552. MULTIVARIATE STATISTICAL ANALYSIS (3) Application of statistical methods for analyzing the relationships between two or more variables, such as multiple regression. Prerequisite: 3 credits in statistics.

ADMIN. 556. ECONOMIC AND BUSINESS FORECASTING (3) Application and evaluation of methods for forecasting regional economic change and business activity. Prerequisites: Bus. 380, Econ. 310.

ADMIN. 560. SAMPLING THEORY AND PRACTICE (3) Study of scientific method of obtaining representative samples, collection of information, techniques of estimation. Prerequisite: Bus. 493.

ADMIN. 590. COLLOQUIUM (1-3)

ADMIN. 596. INDIVIDUAL STUDIES (1-6)

ADMIN. 597. SPECIAL TOPICS (1-6)

BUS. 522. OPERATIONS MANAGEMENT (3) Integration and application of decision making to operational and policy problems within the business firm. Prerequisite: Admin. 520.

BUS. 530. FINANCIAL MANAGEMENT (3) Theory and techniques of financial management. Cover analysis, planning and control; sources of funds; allocation of funds; special situation analysis. Prerequisites: Admin. 520, Bus. 320.

BUS. 540. FINANCIAL AND MANAGERIAL ACCOUNTING (3) Fundamental financial and managerial accounting concepts and issues from the viewpoint of the report user. Prerequisite: 6 credits of introductory accounting.

BUS. 554. MASTER'S PROJECT (1-3) Development of an original master's project in the student's area of professional interest.

BUS. 570. MARKETING MANAGEMENT (3) Analysis of management's marketing problems, including marketing analyses, pricing, channels of distribution, promotion, competition, product strategies, and marketing research.

BUS. 571. CONSUMER BEHAVIOR (3) Factors influencing buyer behavior; contributions of the behavioral sciences to the study of selected phenomena. Prerequisite: Econ. 410.

BUS. 584. GOVERNMENT AND BUSINESS (3) Theory, practice, and impact of government regulation of business. Prerequisite: Econ. 410 or 417.

*BUS. 588. BUSINESS POLICY FORMULATION (3) Analysis of administrative problems from a total organization viewpoint. Case studies of actual organizations are used for analysis. Prerequisites: all core and tool courses.

BUS. 597. SPECIAL TOPICS (1-6)

B.LOG. 538. LOGISTICS SYSTEMS MANAGEMENT (3)

B.LOG. 541. SOCIOECONOMIC ANALYSIS IN TRANSPORTATION (3)

I.B. 501. THE INTERNATIONAL ENVIRONMENT (3)

*Course to be taken during student's last term — recommend tool courses be completed.

- I.E. 508. OPERATIONS RESEARCH: INVENTORY MODELS (3)
 I.E. 509. OPERATIONS RESEARCH: WAITING LINE MODELS (3)
 I.E. 510. MATHEMATICAL PROGRAMMING (3)

AEROSPACE ENGINEERING (AERSP)

BARNES W. McCORMICK, *Head of the Department*
 233 Hammond Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Eisenhuth, Holl, Kaplan, Lakshminarayana, McCormick, Parkin, Phillips, and York.

Graduate Faculty: Associate Members Hoffman, Morris, and Thompson.

Opportunities are available for graduate study in the following areas: low-speed aerodynamics, V/STOL aircraft, turbulence, astrodynamics, turbomachinery, aeroacoustics, plasma dynamics, rarefied gas dynamics, hydrodynamics, stability and control of aerospace vehicles, aeroelasticity, and aerospace structures.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by providing proof of mature and meaningful knowledge in a cultural subject of broad significance as a substitute for one of these languages, or by a comprehensive knowledge of one foreign language.

The entering student must hold a bachelor's degree in physical science, mathematics, or engineering and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if not already completed. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

AEROSPACE ENGINEERING (AERSP)

402. AEROSPACE DESIGN (2)
 404. AEROSPACE ENGINEERING LABORATORY (2)
 405. EXPERIMENTAL METHODS IN AEROSPACE ENGINEERING (3)
 407. AERODYNAMICS OF V/STOL AIRCRAFT (3)
 410. AEROSPACE PROPULSION (3)
 411. AEROELASTICITY (3)
 412. TURBULENT FLOW (3)
 413. STABILITY AND CONTROL OF AIRCRAFT AND MISSILES (3)
 415. PHYSICAL GAS DYNAMICS (3-6)
 416. INTRODUCTION TO RESEARCH AND DESIGN (1)
 417. AEROSPACE THESIS (2)
 420. PRINCIPLES OF FLIGHT TESTING (3)
 421. (M.E. 421) INTERMEDIATE VISCOUS FLOW (3)
 425. THEORY OF FLIGHT (3)
 430. SPACE PROPULSION AND POWER SYSTEMS (3)
 444. NOISE POLLUTION OF FLUID DYNAMIC ORIGIN (3)
 450. ORBIT AND ATTITUDE CONTROL OF SPACECRAFT (3)
 496. INDEPENDENT STUDIES (1-12)
504. AERODYNAMICS OF V/STOL AIRCRAFT (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aersp. 407.

505. AERO- AND HYDROELASTICITY (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.
506. CAVITATION (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.
507. THEORY AND DESIGN OF TURBOMACHINERY (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.
508. FOUNDATIONS OF FLUID MECHANICS (3) Mathematical review, fluid properties, kinematics, conservation laws, constitutive relations, similarity principles, the boundary layer, inviscid flow, vorticity dynamics, wave motion.
509. DYNAMIC OF IDEAL FLUIDS (3) Irrotational flow theory, two-dimensional and axisymmetric flows, airfoil theory, complex variables, unsteady phenomena; flow with vorticity, finite wing theory. Prerequisite: Aersp. 508.
510. COMPRESSIBLE FLOW (3) Classification and solution of compressible flow problems, high speed gasdynamics, unsteady motion, transonic and hypersonic flows, atmospheric reentry.
511. AERODYNAMICALLY INDUCED NOISE (3) Review of fluid mechanics. General theory of aerodynamic sound. Noise radiation from jets, boundary layers, rotors and fans. Structural response.
512. VISCOUS FLOW (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.
514. STABILITY OF LAMINAR FLOWS (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.
515. FOUNDATIONS OF TURBULENCE (3) The mathematics underlying turbulence theory: descriptions, kinematics of stochastic fields; techniques of solution of linear and some nonlinear problems.
516. HOMOGENEOUS TURBULENCE (3) Dynamics: production, spectral transfer, dissipation, decay of energy; similarity theories.
517. INHOMOGENEOUS TURBULENCE (3) Dynamics: similarity, structural hypotheses; spatial, spectral budget of energy in a number of classical flows.
518. DYNAMICS AND CONTROL OF AEROSPACE VEHICLES (3) Dynamical problems of aircraft and missiles including launch, trajectory, optimization, orbiting, reentry, stability and control, and automatic control. Prerequisite: Aersp. 413 or 450.
550. ASTRODYNAMICS (3) Applications of classical celestial mechanics to space flight planning. Determination and construction of orbital parameters by approximation methods. Perturbation techniques. Prerequisite: Aersp. 450 or Astro. 460 or E.Mch. 410 or Phys. 419.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

AGRICULTURAL ECONOMICS (AG EC)

JOHN W. MALONE, JR., *Head of the Department of Agricultural Economics and Rural Sociology*
6A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Epp, Frey, Gamble, Hallberg, Herrmann, Holt, Hutton, Jansma, Madden, Malone, McAlexander, Partenheimer, Pasto, Schutjer, and Stemberger.

Graduate Faculty: Associate Members Alter, Beierlein, Cordes, Crowley, Daugherty, Dum, Dunn, Fedeler, Fuller, Goode, Haessel, Henson, Smith, Weaver, and Young.

The graduate program emphasizes economic theory and analytical techniques in the fields of farm management, production economics, agricultural marketing, resource economics, rural development, agricultural policy and prices, and in international agricultural trade and development.

There is no foreign language requirement for the Ph.D. degree; rather, the student must satisfactorily complete courses in economic theory and quantitative methods.

Students entering the M.S. program should have 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either field. Students entering the Ph.D. program should have successfully completed courses in intermediate micro- and macroeconomic theory, in differential and integral calculus and linear algebra, and in introductory statistics. Students are permitted to enter the M.S. and Ph.D. programs with deficiencies but must pass courses to eliminate deficiencies as soon as possible.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. TOEFL scores are required, and Graduate Record Examination scores are optional, for applicants whose first language is not English. All other applicants are required to submit Graduate Record Examination scores.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

Students may qualify for admission to the program in population issues consisting of interdisciplinary course work with special emphasis on the economic, social, and geographic issues arising from the dynamics of population change.

AGRICULTURAL ECONOMICS (AG EC)

407. FARM PLANNING AND FINANCIAL MANAGEMENT (3) *Fedeler*
410. AGRICULTURAL REAL ESTATE APPRAISAL (3) *Holt*
420. AGRICULTURAL PRICES (3) *Stemberger*
421. LAND ECONOMICS (3) *Frey and Gamble*
422. LAND AND WATER RESOURCE POLICY (3) *Alter*
450. INTERNATIONAL AGRICULTURAL TRADE AND DEVELOPMENT (3) *Schutjer*
460. INDUSTRIAL ORGANIZATION IN FOOD PROCESSING AND DISTRIBUTION (3) *Dunn*
461. DECISION MAKING IN AGRICULTURAL MARKETING FIRMS (3) *Beierlein*
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. SEMINAR IN AGRICULTURAL ECONOMICS (1-6) Review of current literature and problems.
501. ECONOMICS OF COMMERCIAL AGRICULTURE (3) Application of economic concepts to problems and policies involving agricultural firms, the agricultural industry, and the general agricultural economy. Prerequisite: Econ. 502. *Fedeler*
502. ECONOMICS OF NATURAL RESOURCES AND RURAL DEVELOPMENT (3) Emphasis will be placed on the application of economic concepts to problems and policies in rural areas. Prerequisites: Econ. 502, 503. *Goode*
504. SEMINAR IN AGRICULTURAL POLICY (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy making. Prerequisites: Ag.Ec. 420, Econ. 405. Odd years. *Hallberg*
505. ADVANCED AGRICULTURAL STATISTICS (3) Multiple correlation, curve fitting, analysis of variance, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics. *Haessel*
507. SEMINAR IN FARM MANAGEMENT (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ. 14. *Partenheimer*
509. CONCEPTS OF ECONOMETRIC THEORY (3) Concepts underlying the application of econometric methods to economic problems; identification and multiple equation models; hypothesis testing and decision theory. Prerequisites: Econ. 502, 503. *Haessel*

514. SURVEY RESEARCH TECHNIQUES IN AGRICULTURAL ECONOMICS (3) Survey methods and design of samples for obtaining economic data from business-unit and household populations. Prerequisite: Ag. 400. Odd years.
520. FARM PRICE ANALYSIS (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. Odd years. *Weaver*
524. RESOURCE ECONOMICS (3) Economic aspects of resource use and development: economic growth, land-use planning and control, conservation, resource investment criteria and policies. Prerequisite: Ag.Ec. 421 or 422. *Epp*
525. RESEARCH METHODS IN RURAL SOCIAL SCIENCES (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences.
527. SEMINAR IN APPLIED QUANTITATIVE METHODS (1-4) *Beierlein and Partenheimer*
534. AGRICULTURAL PRODUCTION ECONOMICS (2) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change. Prerequisite: Econ. 502. Even years. *Dunn*
571. SEMINAR IN LAND AND WATER RESOURCE ECONOMICS (3) Critical review of research in resource economics; consideration of special topics in resource use. *Goode*
596. INDIVIDUAL STUDIES (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

AGRICULTURAL EDUCATION (AG ED)

GENE M. LOVE, *Head of the Department*
102 Armsby Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Curtis, Love, and Stinson.

Graduate Faculty: Associate Members Evans, Heinsohn, Howell, Lindley, Mortensen, Morton, and Yoder.

Graduate programs emphasize the professional improvement of teachers and of agricultural extension personnel with education responsibilities. They provide advanced preparation for employment in administration, supervision, teaching including teacher education, and research in agricultural education and related fields. A minor may be taken in an area of agricultural science, technology, or in general studies. Programs may include courses needed for certification in other fields of education. Successful completion of one year of teaching or equivalent professional experience is required prior to completion of the M.S. or M.Ed. degree.

There are no foreign language requirements for the Ph.D. in agricultural education; however, Engl. 418 and Sp.Com. 212 or equivalent communication courses are required.

Admission to a doctoral program requires (1) a 3.00 grade-point average for graduate work, (2) a minimum of two years of successful public, private, or extension teaching experience before the degree is completed, (3) evidence of ability to write a scholarly paper or thesis, and (4) a teaching-level competence in English.

Prerequisite for admission to a master's program is a minimum of 18 credits in professional education courses — including educational psychology and student teaching — or certification as a teacher of agriculture or equivalent professional experience. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission to M.S. or M.Ed. programs. The best-qualified applicants for all degrees will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point averages may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL EDUCATION (AG ED)

- 400v. EDUCATIONAL PROGRAMS IN AGRICULTURE FOR DEVELOPING COUNTRIES (3)
- 418v. SURVEY OF VOCATIONAL EDUCATION IN AGRICULTURE (1-4)
- 420v. INSTRUCTIONAL MEDIA IN AGRICULTURE (1-6)
- 422v. SUPERVISION OF VOCATIONAL EDUCATION IN AGRICULTURE (1-4)
- 424v. OCCUPATIONAL GUIDANCE IN AGRICULTURAL INDUSTRY (1-4)
- 426v. ADULT EDUCATION IN AGRICULTURE (1-4)
- 434v. AGRICULTURAL DEVELOPMENTS (1-6)
- 440. COMMUNICATION METHODS AND MEDIA IN AGRICULTURE (3)
- 450. METHODOLOGY OF EXTENSION EDUCATION (3)
- 490, 490v. COLLOQUIUM (1-3)
- 496, 496v. INDEPENDENT STUDIES (1-12)
- 497, 497v. SPECIAL TOPICS (1-6)

- 501v. AGRICULTURAL EDUCATION IN THE UNITED STATES (1-3) Historical development, social and philosophical foundations, and current status in relation to the total vocational-technical education program.
- 502v. TEACHING AGRICULTURE (1-3) Vocational education objectives, learning theory, class instruction, cooperative occupational experience, and evaluation.
- 508v. ADMINISTRATION AND SUPERVISION OF AGRICULTURAL EDUCATION (1-3) Administration of state and district systems of vocational-technical education; supervision of teachers of agriculture.
- 509v. TEACHER EDUCATION IN AGRICULTURE (1-6) Organization and administration of university programs of teacher education in agriculture, including preservice preparation, continuing education, research, and other services.
- 520v. SCIENTIFIC METHOD IN THE STUDY OF AGRICULTURAL EDUCATION (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education.
- 521v. SCIENTIFIC METHOD IN THE STUDY OF AGRICULTURAL EDUCATION (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems.
- 524v. PROGRAM DEVELOPMENT IN AGRICULTURAL EDUCATION (1-3) Analysis of occupational needs of students and employment prospects; organization of courses of study and other activities of teachers.
- 530. AGRICULTURAL COLLEGE TEACHING (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, techniques of teaching, and measurement of results of teaching.
- 590, 590v. COLLOQUIUM (1-3)
- 596, 596v. INDIVIDUAL STUDIES (1-6)
- 597, 597v. SPECIAL TOPICS (1-6)

AGRICULTURAL ENGINEERING (AG E)

HAROLD V. WALTON, *Head of the Department*
250 Agricultural Engineering Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aldrich, Bartlett, Mohsenin, Morrow, Persson, Stephenson, and Walton.

Graduate Faculty: Associate Members DeTar, Hoover, Keppeler, Kjølgaard, and Schroeder.

Graduate programs are available in the areas of the physical properties of biomaterials, protected plant and animal production, food physics and engineering, agricultural structures, agricultural byproduct utilization, agricultural systems engineering, biomass energy conversion, alternative energy sources, agronomic crop mechanization, forage and animal interaction, horticultural engineering, microclimate modification, soil dynamics, and infiltration, drainage, and irrigation.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by either (1) 9 credits of courses in an approved sequence or (2) a foreign language. Prior approval by the Ph.D. Advisory Committee must be obtained to study a foreign language other than French, German, Russian, or Spanish.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are freeze-drying equipment for drying by sublimation, controlled environmental chambers, plant growth structures for modified atmosphere, a general-purpose analog computer, data processing systems including remote job entry for access to University computer facilities, and laboratories for research on physical properties of agricultural materials. Special equipment is available for physical properties work, including Instron and Ametek testing machines complete with environmental chambers and data acquisition systems, a polariscope for photoelastic stress analysis, triaxial testing equipment, and other unique and specially designed testing facilities. Special facilities outside the Agricultural Engineering Building include a mushroom research and demonstration facility, an anaerobic digester for methane gas generation, and greenhouses designed for solar energy utilization and energy conservation studies.

Prerequisite to major work is the completion of an undergraduate major in engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL ENGINEERING (AG E)

401. FARM MECHANICS FOR TEACHERS OF VOCATIONAL AGRICULTURE (1½-9)
402. FUNCTIONAL DESIGN OF AGRICULTURAL STRUCTURES (3)
403. PHYSICAL PROPERTIES OF AGRICULTURAL MATERIALS (3)
404. AGRICULTURAL MACHINERY (3)
405. AGRICULTURAL PROCESS ENGINEERING (3)
407. SOIL WATER ENGINEERING (3)
408. INSTRUMENTATION FOR AGRICULTURAL PRODUCTION AND PROCESSING (3)
409. AGRICULTURAL SYSTEMS ENGINEERING (3)
410. POWER FOR AGRICULTURAL SYSTEMS (3)
412. PHYSICAL PROCESSES IN FOOD MANUFACTURING I (3)
413. PHYSICAL PROCESSES IN FOOD MANUFACTURING II (3)
414. PHYSICAL PROCESSES IN FOOD MANUFACTURING III (2)
420. SEMINAR (1)
423. PHYSICAL AND RHEOLOGICAL MEASUREMENTS ON BIOMATERIALS (3)
424. FARM MACHINERY MANAGEMENT (3)
457. LAND WASTE DISPOSAL (3)
490. AGRICULTURAL MECHANIZATION SEMINAR (1)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. ADVANCED ELECTRO-AGRICULTURE (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.
501. ADVANCED FARM MACHINERY (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.
502. FARM STRUCTURES PROBLEMS (1-6) Analysis of farm structures design problems.

giene, illumination, noise, safety, mine drainage, land reclamation, waste disposal); and rock mechanics (stress analysis, roof and ground control, penetration, fragmentation, subsidence).

Students who desire to obtain the Master of Engineering degree in mining engineering must take a minimum of 30 credits (including at least 12 credits at the 500 level) of appropriate courses in the major area and elective courses. A scholarly written report is also required. Programs of study are available in general mining engineering, rock mechanics, mine operations, research systems engineering, internal or external mine environmental control, mine health and safety; and emphasis can be given to any of the areas listed above.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by completion of courses in two languages or by completion of courses in one language and 6 credits of computer science. A thesis is required for the M.S. degree.

A bachelor's degree in mining engineering or a related engineering field is required for admission. Students may be required to make up deficiencies in their area of specialization. Certain basic related courses outside the department may be approved as part of the major. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

MINING (MNG)

400. MINING AND OUR ENVIRONMENT (3)
 402. MINE PLANT DESIGN (3)
 403. MINE POWER SYSTEM AND COMMUNICATION DESIGN (3)
 410. MINING ENGINEERING ANALYSIS (3)
 411. MINE SYSTEMS ENGINEERING (3)
 422. MINE VENTILATION AND AIR CONDITIONING (3)
 431. ROCK MECHANICS (3)
 441. SURFACE MINING SYSTEMS AND DESIGN (3)
 451. ADVANCED MINING ENGINEERING (1-3)
-
502. MINE POWER SYSTEM PROTECTION (3) Protective circuitry, coordination, transient protection, and hazard reduction applied to mine power systems. Prerequisite: Mng. 403 or E.E. 425.
 513. MINE COST ANALYSIS (3) Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records.
 514. MINE OPERATIONS ANALYSIS (3) Application of operations research techniques in determining optimal design and operating policies for mine management. Prerequisite: Mng. 411.
 515. MINE SYSTEMS SIMULATION (3) Principles and practices of probabilistic and deterministic simulation in the analysis of operating systems related to mills and mines. Prerequisites: Cmp.Sc. 401, Pk. 411.
- law
- RHEOLOGICAL AND STRENGTH CHARACTERISTICS OF ROCKS (3) Properties of rocks and their deformation; failure theories; brittle to ductile transition; rheological behavior. Prerequisite: Mng. 411.
- master
- logical
- made for
- will be evaluated
- best-qualified
- chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisite: Mng. 13, Mng. 30, Psy. 203.
- AGRICULTURAL CONTROL ENGINEERING (3) Theoretical considerations; convergence, abutments, rockbursts; underground support systems; design of mine openings. Prerequisite: Mng. 401.

MUSIC

545. ROCK MECHANICS INSTRUMENTATION (3) Strain gauge circuitry, transducers, electrohydraulic servo installations, and integrated strain and force measuring systems as applied to rock mechanics. Prerequisite: Mng. 431.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

MUSIC (MUSIC)

ROBERT W. BAISLEY, *Head of the Department*
232 Music Building

Degrees Conferred: M.A., M.Mus.

Graduate Faculty: Senior Members Baisley, Brinsmaid, Brown, Fenner, and D. Miller.

Graduate Faculty: Associate Members J. Feldman, L. Feldman, P.J. Miller, and Perison.

The Master of Arts degree is academic in nature, and the program is directed toward musicological research. Admission requires the completion of a recognized music major or its equivalent, and a reading knowledge of one foreign language, either French or German. A thesis is required of all M.A. candidates. While 30 credits are listed as a minimum requirement, it should be noted that the amount of course work necessary may exceed the minimum, according to the needs and background of the student involved.

The Master of Music degree program is planned to provide professional emphasis. Students will specialize in either performance or composition. In addition to credit requirements, admission to the program is contingent upon department certification of the candidate's competence. According to the area of specialization, an audition or submission of manuscripts is required. Arrangements for this can be made by the student with the department. While 48 credits are listed as a minimum requirement, it should be noted that the amount of course work necessary may exceed the minimum according to the needs and background of the student involved.

Students who lack the recommended upper-class courses in music may be required to take additional course work without receiving graduate credit.

The department sponsors musical activities, and candidates for both degrees are required to participate in positions of responsibility. All candidates for degrees are expected to be in residence for a minimum of three consecutive terms.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests. All applicants for graduate degrees must take the Graduate Record Examination, including the Advanced Music Examination.

MUSIC (MUSIC)

410. MUSIC OF THE TWENTIETH CENTURY (3)

412. MUSIC OF THE BAROQUE PERIOD (3)

413. MUSIC OF THE MIDDLE AGES (3)

414. MUSIC OF THE RENAISSANCE (3)

417. MUSIC OF THE CLASSICAL PERIOD (3)

418. MUSIC OF THE ROMANTIC PERIOD (3)

*429. VOCAL STYLE (3 per term, maximum of 18) Fee \$100.

455. FORM AND ANALYSIS (2)

*Course may be scheduled only after consultation with the head of the department.

503. **PHYSICAL PROPERTIES OF PLANT AND ANIMAL PRODUCTS (3)** Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.
505. **EXPERIMENTAL AND APPLIED INSTRUMENTATION (4)** The theory and application of electronics for instrumentation and experimental research.
507. **PROBLEMS IN SOIL WATER ENGINEERING (1-6)** Analysis of engineering problems relating to irrigation, drainage, or erosion control.
509. **RESEARCH IN AGRICULTURAL ENGINEERING (1-4)**
520. **AGRICULTURAL ENGINEERING SEMINAR (1-3)** Reports on research and special topics.
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

AGRONOMY (AGRO)

JAMES L. STARLING, *Head of the Department*
117 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Baker, Bollag, Ciolkosz, Cleveland, Cunningham, Duich, Fritton, Hall, Harrington, Heald, Hill, L. Johnson, M. Johnson, Jung, Kendall, Marshall, McKee, Petersen, Risius, Shenk, Starling, Waddington, and Watschke.

Graduate Faculty: Associate Members Baylor, Cole, Fox, Hartwig, Hatley, Knievel, Lanyon, Pennock, Pfeifer, Pionke, Rogowski, and Stringer.

Students may specialize in soil science, crop science, or soil and crop management. Soil science specialties include genesis and morphology, chemistry, biochemistry, fertility, mineralogy, physics, and remote sensing. Crop science specialties include breeding and genetics, crop quality, crop and weed ecology, and physiology.

The communication and foreign language requirement for the Ph.D. degree may be met either by demonstrating a knowledge of at least one foreign language or by completing at least 6 credits of course work in an area of English communications approved by the student's advisory committee.

Prerequisites for major work in agronomy vary with the area of specialization and the degree sought, but courses in chemistry, mathematics, physics, geology, basic and applied biological sciences, and English communication skills are required. Applicants for the M.S. degree should have a baccalaureate degree including 76 credits of basic and applied natural sciences. For the M.Agr. degree program, an applicant must present a baccalaureate degree in agricultural or forest science. Admission to the Ph.D. program requires an M.S. or equivalent degree, and 100 credits (including credits of the baccalaureate degree) of basic and applied natural sciences. Students who lack some of the prerequisite courses may be admitted but are required to take these courses without degree credit.

A minimum junior-senior grade-point average of 3.00 is required for admission to the agronomy master's degree programs. In addition, a grade-point average of 3.00 is required in all courses in the biological and physical sciences regardless of when taken. Exceptions to these requirements may be made for students with special backgrounds, abilities, and interests. Applicants for the Ph.D. program will be evaluated principally on the quality of work completed in previous graduate programs. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

AGRONOMY (AGRO)

401. **SOIL COMPOSITION AND PHYSICAL PROPERTIES (3)** *Fritton and Johnson*
402. **CHEMISTRY OF SOILS AND FERTILIZERS (3)** *Fox*

410. CROP SCIENCE (3) *Knievel*
411. BREEDING OF FIELD CROPS (3) *Cleveland*
415. SOIL MORPHOLOGY, MAPPING, AND LAND USE (3) *Petersen*
416. SOIL GENESIS AND CLASSIFICATION (3) *Ciolkosz*
417. FOREST SOILS (3) *Pennock*
419. SOIL PROPERTIES (4) *Baker*
420. AGRONOMIC CASE STUDIES IN SOIL, PLANT, AND WATER MANAGEMENT (3) *Lanyon*
422. CONSERVATION OF SOIL AND WATER RESOURCES (3) *Cunningham*
423. FORAGE CROP MANAGEMENT (3) *Stringer*
425. FIELD CROP MANAGEMENT (3) *Pfeifer*
438. PRINCIPLES OF WEED CONTROL (3) *Hartwig*
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
501. SOIL FERTILITY (3) Soil-plant relations emphasizing recent concepts of ion accumulation by plants as affected by soil conditions and plant physiology. Prerequisites: Agro. 402, Biol. 441. *Hall*.
506. SOIL PHYSICAL CHEMISTRY (4) Colloidal chemistry of soils emphasizing ion adsorption, double-layer theory, diffusion, and water properties. Prerequisites: Agro. 419; Bioch. 425 or Chem. 451. *Baker*
507. SOIL PHYSICS (3-4) Soil physical properties emphasizing water, heat, gas, and ion movement in unsaturated soils. Laboratory included with 4 credits. Prerequisites: 6 credits each of calculus, physics, and soils. *Fritton*
509. METHODS OF GENETIC ANALYSIS (3) Methods of qualitative genetics. Tests of hypotheses, homogeneity, linkage detection, calculations of recombination values, monosomic analysis, and tetrasomic inheritance. Prerequisite: 6 credits of genetics or plant breeding. *Cleveland*
510. CYTOGENETICS IN PLANT BREEDING (3) Chromosomal heredity of agricultural plants. Chromosome morphology; cytogenetic behavior of aneuploids, haploids, auto- and allopolyploids, and interspecific hybrids. Prerequisite: 6 credits of genetics including 3 credits of cytogenetics or cytology. *Cleveland*
511. BIOMETRICAL PLANT BREEDING (3) Quantitative genetics of plant populations; applications to breeding methodology and selection. Prerequisites: Agro. 512 and 3 credits of plant breeding. *Hill and Risius*
512. FIELD PLOT TECHNIQUE (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Ag. 400 or Stat. 200. *Risius*
515. NUTRITIVE VALUE OF CROP PLANTS (3) Biochemical, physiological, genetic, and morphological nature of crop plants related to animal response. Laboratory includes nutritive evaluation procedures. Prerequisites: 3 credits of crop production and 6 credits of biochemistry and/or nutrition. *Shenk*
517. CROP ECOLOGY AND PHYSIOLOGY (3) Ecological and physiological factors affecting the productivity of crop plants. Prerequisite: Agro. 410. *McKee*
518. RESPONSES OF CROP PLANTS TO ENVIRONMENTAL STRESS (3) Physiological and ecological aspects of the response of crop plants to environmental stresses in establishment, persistence, and reproduction. Prerequisite: Agro. 410. *McKee*
519. NATURE OF SOIL MINERALS (3) Constituent minerals of soils: modern methods for identification; relations to soil formation and agricultural practices. Prerequisite: Agro. 401. *Johnson*
545. THE APPLICATION OF STATISTICS TO FIELD EXPERIMENTS (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. *Risius and Shenk*
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

AMERICAN STUDIES (AM ST)

IRWIN RICHMAN, *In Charge of the Graduate Program in American Studies*
The Capitol Campus, Middletown, PA 17057

Degree Conferred: M.A.

Graduate Faculty: Senior Members Lear, Richman, Tischler, and Wolf.

Graduate Faculty: Associate Members R. Graham, T. Graham, Milspaw, Molovinsky, and Patterson.

This program emphasizes the study of American society as a whole, not as interpreted by a single discipline, but in the larger context of a culture. The purpose of the program is to provide the student with the opportunity to acquire knowledge and understanding within any of the following areas: ethnic composition and demographic problems of the American people; regional characteristics; the technological base of American civilization; economic, political, and social institutions; the media of communication; artistic expression, particularly in art, architecture, literature, and music; philosophy and values; and the dynamics and interrelationships of all of these.

The student is required to take a minimum of 30 credits, including at least 18 credits in the 500 series. A maximum of 24 of these 30 credits shall be taken within the program area. An original, scholarly master's paper or creative production initiated by the student, supervised by an appropriate professor, and judged by a committee is required. One to 6 credits can be accumulated during work on the master's production.

For admission to the master's program, a student must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. Social sciences and the humanities are not required as prerequisites, though it is anticipated that students will have had work in these areas. The application, transcripts, and a letter outlining personal goals and reasons for applying for the program should be sent directly to the Graduate Office, The Capitol Campus, Middletown, PA 17057.

REQUIRED COURSES

AM.ST. 500. THEORY AND METHODS (3) Study of the methods and materials of American Studies scholarship, compilation of bibliographies, the writing of scholarly papers, and proper documentation.

AM.ST. 580. PROJECTS IN AMERICAN STUDIES (1-6) Independent exploration within American Studies; evidenced by major paper, film, exhibition, or specialized examination.

APPROPRIATE COURSES may be taken from the following list and from 500-level courses in other fields with the concurrence of the student's adviser.

AM.ST. 511. PIVOTAL BOOKS (3-9) Exploration of a number of books which have been particularly influential in shaping thinking about American civilization.

AM.ST. 530. TOPICS IN AMERICAN FOLKLORE (3) A detailed exploration of aspects of folklore and folklife in America.

AM.ST. 533. AMERICAN CIVILIZATION IN THE EIGHTEENTH CENTURY (3-9) Detailed investigation of specific topics in eighteenth-century American civilization.

AM.ST. 534. AMERICAN CIVILIZATION IN THE NINETEENTH CENTURY (3-9) Representative interdisciplinary investigation of social, historical, economic, and aesthetic forces predominant in nineteenth-century America.

AM.ST. 535. AMERICAN CIVILIZATION IN THE TWENTIETH CENTURY (3-9) Detailed investigation of specific periods or topics in twentieth-century American civilization.

AM.ST. 570. TOPICS IN AMERICAN ART (1-6) Various themes within the American arts will be explored under this rubric.

AM.ST. 575. MUSEUM INTERNSHIP (3) A supervised museum internship experience featuring a "hands-on" introduction into aspects of the curatorial profession.

- AM.St. 590. COLLOQUIUM (1-3)
 AM.St. 596. INDIVIDUAL STUDIES (1-6)
 AM.St. 597. SPECIAL TOPICS (1-6)

ADDITIONAL COURSES may be taken from the following list and from 400-level courses in other fields with the concurrence of the student's adviser.*

- AM.St. 400. AMERICAN COLONIAL EXPERIENCE
 AM.St. 401. AMERICAN REVOLUTION AND EARLY NATIONAL EXPERIENCE
 AM.St. 403. INTELLECTUAL FOUNDATIONS OF AMERICAN CULTURE (3)
 AM.St. 422. WESTERN MOVEMENT
 AM.St. 431. THE AMERICAN CHARACTER
 AM.St. 442. AMERICAN FOLKLORE
 AM.St. 445. AMERICAN PHILOSOPHY
 AM.St. 451. CIVIL WAR AND RECONSTRUCTION
 AM.St. 452. THE AMERICAN RENAISSANCE
 AM.St. 453. THE GILDED AGE AND THE PROGRESSIVE IMPULSE
 AM.St. 454. AMERICA'S POLITICAL PARTIES
 AM.St. 456. MASS CULTURE: THE POPULAR ARTS IN AMERICA
 AM.St. 457. IMMIGRANTS AND AMERICANS
 AM.St. 458. CONTEMPORARY AMERICA
 AM.St. 459. AMERICA'S COMING OF AGE 1914-1939
 AM.St. 460. AMERICAN ART AND ARCHITECTURE
 AM.St. 463. AMERICAN MUSIC
 AM.St. 469. AMERICAN INDIAN ETHNOLOGY
 AM.St. 470. REGIONALISM IN AMERICA
 AM.St. 474. (Econ. 474) AMERICAN ECONOMIC DEVELOPMENT
 AM.St. 475. THE AMERICAN IMPACT ABROAD
 AM.St. 476. INTERACTION — CANADA AND THE UNITED STATES (3)
 AM.St. 479. UNITED STATES DIPLOMATIC HISTORY
 AM.St. 480. MUSEUMS AND CULTURE
 AM.St. 491. SEMINAR IN AMERICAN CULTURE
 AM.St. 496. INDEPENDENT STUDIES (1-12)
 AM.St. 497. SPECIAL TOPICS (1-6)
 So.Sc. 403. CONTEMPORARY U.S. FOREIGN POLICY
 So.Sc. 470. THE PRESIDENCY AND THE EXECUTIVE PROCESS

ANATOMY (ANAT)

BRYCE L. MUNGER, *Chairman of the Department*
 The Milton S. Hershey Medical Center
 Hershey, PA 17033

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baird, Leure-duPree, Munger, Page, Pubols, and Zagon.

Graduate Faculty: Associate Member McCallister.

The graduate program emphasizes the general areas of gross anatomy, histology/cytology, neuroanatomy/neurophysiology, or appropriate combinations of these areas. Approaches offered include morphological (descriptive, comparative, developmental), functional (physiological, chemical), and experimental. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

*Descriptions of these courses may be found in *The Capitol Campus Catalog*.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants must provide complete transcripts and two letters of recommendation. Scores from the Graduate Record Examination and a personal interview are desirable.

This program is offered only at The Milton S. Hershey Medical Center.

ANATOMY (ANAT)

501. FUNDAMENTALS OF GROSS ANATOMY I (3) Macroscopic structure of the upper extremity, head, and neck, with emphasis on normal organization, functional correlations, and clinical significance.

502. FUNDAMENTALS OF GROSS ANATOMY II (3) Macroscopic structure of the thorax, abdomen, pelvis, and lower extremity, with emphasis on normal organization, functional correlations, and clinical significance. Prerequisite: Anat. 501.

505. MICROSCOPIC ANATOMY (4) Microscopic organization of tissues and cells; interrelationships of cells; chemical and functional specializations of cells.

510. NEUROBIOLOGY (3) Morphology and function of the sense organs, general organization of the brain, and physiological studies of central nervous system function.

512. HUMAN EMBRYOLOGY (2) A basic study of the development of the human embryo including gamete production and fusion, implantation, and organogenesis.

513. COMPARATIVE MORPHOGENESIS (3) A descriptive and experimental study of vertebrate and invertebrate development.

515. DEVELOPMENTAL NEUROBIOLOGY (2) Development of the nervous system in all aspects.

530. DISSECTION (2-4) Intensive laboratory study of selected regions of the human body. Coverage and credit arranged by consultation.

535. SUBMICROSCOPIC ANATOMY (3) Current literature on molecular and micellar organization of cells and tissues in diverse systems; application of interference and electron microscopy. Prerequisite: Anat. 505.

542. COMPARATIVE NEUROLOGY (3) Topics in functional anatomy and neurophysiology. The comparative approach to the organization of the mammalian nervous system will be stressed. Prerequisite: Anat. 510.

543. SENSORY PROCESSES (3) Morphological, physiological, and psychophysical aspects of mammalian sensory systems; emphasizing somatic, sensory, visual, and auditory systems. May be repeated. Prerequisite: Anat. 510.

545. COMPARATIVE AUDITORY AND VISUAL ANATOMY (3-5) An introduction to the morphology and evolution of the vertebrate eye and ear; individualized laboratory work arranged by consultation.

550. SEMINAR IN QUANTITATIVE OPTICS (3) Study of the various types of light microscopy instruments and application of these tools to quantitative measurements in biological systems. Prerequisite: Anat. 505.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

ANIMAL INDUSTRY (A I)

G. W. SHERRITT, *Chairman, Graduate Program in Animal Industry*
325 Animal Industries Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Baumgardt, Cowan, Hershberger, Long, Sherritt, Sink, Wangsness, Wilson, and Ziegler.

Graduate Faculty: Associate Members Burdette, Cash, Hagen, Harpster, King, and Merritt.

Opportunities are available for graduate study and research in breeding and genetics, nutrition and feed technology, physiology, animal management systems, growth and body composition, and meat science. Ruminant, nonruminant, small animal, and wildlife species are available.

The M.Agr. is a professional program designed to prepare individuals for specialist and management positions in county agricultural extension, government, or industry and does not require a thesis. The academic M.S. and Ph.D. programs require a thesis and are designed for those primarily interested in education and research. The requirements of these programs are detailed in the departmental publication, *Requirements of the Graduate Programs in Animal Industry*. The communication and foreign language requirements for the Ph.D. degree may be satisfied by competence in either one foreign language or communications skills.

For admission the student must complete an undergraduate major in animal science or a closely related field. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without graduate degree credit. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

ANIMAL INDUSTRY (A I)

- 406. SWINE MANAGEMENT AND PRODUCTION (3)
- 407. ADVANCED HORSE PRODUCTION AND MANAGEMENT (2)
- 408. SHEEP PRODUCTION AND MANAGEMENT (3)
- 409. BEEF PRODUCTION AND MANAGEMENT (3)
- 423. ADVANCED LIVESTOCK SELECTION (2)
- 424. ANIMAL INDUSTRY SEMINAR (1 per term)
- 431. ADVANCED MEAT SELECTION AND GRADING (2)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501. PEDIGREE STUDY (1-6) Research work in breed study history, and analytical study of breed pedigrees, and a complete survey of the herd, flock, or stud book.

505. ADVANCED ANIMAL BREEDING (1-5) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: An.Sc. 322.

510. ANIMAL SCIENCE RESEARCH METHODS (3) Application of scientific method; experimental design and procedures; analyzing, interpreting, and reporting research results. Prerequisite: Ag. 400.

514. ANIMAL GROWTH AND DEVELOPMENT (3) Animal life cycles; nature of growth and development; effects of biological, environmental, social, and psychological variants; homeostasis and organismic theory. Prerequisites: 3 credits in biochemistry and 3 credits in physiology.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

NOTE: See *Animal Nutrition, Physiology, and Food Science*. Also see *Animal Science* under "Other Graduate Courses."

ANIMAL NUTRITION (A NTR)

ROBERT L. COWAN, *Chairman of the Committee on Animal Nutrition*
301 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baumgardt, Cowan, Hartsook, Hershberger, Kesler, Leach, McCarthy, Mendez, Muller, Scholz, and Wangness.

Graduate Faculty: Associate Members Harpster and Shellenberger.

This is an interdepartmental graduate program designed to enable students to obtain thorough training in animal nutrition. The program is under the direction of a committee composed of graduate faculty members of the Departments of Animal and Dairy Science, Poultry Science, and Veterinary Science, and the Human Performance Research Laboratory. Programs are offered in ruminant and nonruminant nutrition, including: physiology of nutrition; nutritional requirements for productive functions; metabolism of carbohydrates, lipids, proteins, vitamins, and minerals; and regulation of food intake and other metabolic functions.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages.

Undergraduate preparation should include organic and analytical chemistry, physics, biology, and mathematics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiencies without graduate credit.

Students should have an appropriate background and a 3.00 average in the major area and in related sciences for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum requirements may be made for students with special backgrounds, abilities, and interests.

The following nutrition courses are offered by participating departments, and their descriptions may be found under the listings of the respective departments: D.Sc. 511, Pty.Sc. 502, and V.Sc. 535. Courses related to animal nutrition can be found under the following listings in this bulletin: Animal Industry, Biochemistry, Dairy Science, Food Science, Physiology, Poultry Science, and Veterinary Science. For other graduate courses in this subject area see courses listed under Nutrition such as Nutr. 552, 556, and 557.

ANIMAL NUTRITION (A NTR)**400. NUTRITION AND FEED TECHNOLOGY (3)****401. PHYSIOLOGY OF NUTRITION (3)**

501. ENERGY METABOLISM (2) Integration of biochemical and physiological processes in energy metabolism; concepts underlying the application of bioenergetics and calorimetry to body functions. Prerequisites: 3 credits each in biochemistry and physiology.

503. MICRONUTRIENTS: NUTRITION, METABOLISM, AND FUNCTION (2) Functional approach to the study of vitamins and trace elements in the nutrition and metabolism of animals and man. Prerequisites: 3 credits each in biochemistry, nutrition, and physiology.

505. RUMINOLOGY (3) Physiological, biochemical, and microbiological activities occurring within the rumen and the relation of rumen function to animal response. Prerequisites: at least one course in each of the following areas: animal nutrition, physiology, microbiology, and biochemistry.

590. COLLOQUIUM (1-3)
 596. INDIVIDUAL STUDIES (1-6)
 597. SPECIAL TOPICS (1-6)

ANTHROPOLOGY (ANTHY)

WARREN T. MORRILL, *Head of the Department*
 409 Carpenter Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members P. Baker, Chagnon, Escobar, Hunt, Michels, Morrill, and Sanders.

Graduate Faculty: Associate Members T. Baker, Dyke, Eckhardt, Hatch, Kurland, Nydegger, and Webster.

The master's program is designed to train students in general anthropology. The doctoral program is structured to train students in the following areas of specialization: social anthropology, cultural evolution and ecology, analytic archaeology, archaeological technology, archaeology culture areas, or human biology including human physiology, adaptability, biological determinants of human behavior, demography, and human evolution.

M.A. candidates may submit either a thesis or a term paper. If the latter is chosen, 6 credits in 500-level courses in the major field must be scheduled in lieu of thesis credits. The M.A. degree may be bypassed by exceptional candidates for the Ph.D. degree.

The communication and foreign language requirement for the Ph.D. degree includes a reading knowledge of a foreign language plus an option from among additional foreign languages, field languages, linguistics, and statistics.

Undergraduate preparation must include 12 credits in anthropology and archaeology or their equivalent. A student with an excellent record but who does not meet these requirements may be admitted provided course deficiencies are made up without graduate credit. Students with a 3.00 or higher junior-senior average and with appropriate course backgrounds who have research interests directly related to the special anthropological competences within the department will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ANTHROPOLOGY (ANTHY)

- 400. HUMAN EVOLUTION: THEORY AND PROCESS (3)
- 401. HUMAN EVOLUTION: THE MATERIAL EVIDENCE (3)
- 402. HUMAN ECOLOGY (3)
- 405. PRIMATOLOGY (3)
- 408. DEMOGRAPHIC METHODS IN ANTHROPOLOGY (3)
- 409. ANALYTIC METHODS LABORATORY (1)
- 414. SYSTEMATIC INSTRUCTION IN ANTHROPOLOGY (3)
- 415. (C.F.Ed. 415) ANTHROPOLOGY OF EDUCATION (3)
- 420. ARCHAEOLOGY OF THE NEAR EAST (3)
- 421. ARCHAEOLOGY OF THE CENTRAL ANDES (3)
- 422. ARCHAEOLOGY OF MESO-AMERICA (3)
- 423. ARCHAEOLOGY OF EASTERN UNITED STATES (3)
- 424. ARCHAEOLOGY OF AFRICA (3)
- 440. SOUTH AMERICAN TRIBAL SOCIETIES (3)
- 441. ETHNOLOGY OF THE ANDEAN REGION (3)
- 442. EUROPEAN PEASANTRY (3)
- 444. ETHNOLOGY OF MESO-AMERICA (3)

446. ETHNOLOGY OF NORTH AMERICA (3)
 447. ETHNOLOGY OF SUB-SAHARAN AFRICA (3)
 448. ETHNOLOGY OF THE MIDDLE EAST (3)
 449. ETHNOLOGY OF SOUTHEAST ASIA (3)
 450. COMPARATIVE SOCIAL ORGANIZATION (3)
 451. ECONOMIC ANTHROPOLOGY (3)
 453. (Soc. 453) PRIMITIVE RELIGION (3)
 454. POLITICAL ANTHROPOLOGY (3)
 455. CULTURE AND PERSONALITY (3)
 456. CULTURAL ECOLOGY (3)
 457. LANGUAGE IN CULTURE (3)
 458. PRIMATE SOCIOBIOLOGY (3)
 460. ANTHROPOLOGICAL THEORY (3)
 461. METHODS IN CULTURAL ANTHROPOLOGY (3)
 462. METHODS IN ARCHAEOLOGY (3)
 464. TRIBAL SOCIETIES (3)
 471. HISTORY OF ANTHROPOLOGICAL THEORY (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
500. HUMAN EVOLUTION (3) Theoretical problems in analysis of human evolution. Prerequisite: one course in human genetics or physical anthropology.
501. EVOLUTION OF HUMAN BEHAVIOR (3) The application of evolutionary theory to the study of man's structure, function, and culture. Prerequisites: Anthy. 21 or 401, and 3 additional credits in anthropology, sociology, or psychology.
502. HUMAN ECOLOGY THEORY (3) Analysis of interaction of physical, biological, and cultural factors in human adaptation. Prerequisite: 3 credits in physical anthropology.
504. SOCIAL AND CULTURAL CHANGE (3) Theories and methods used in the analysis of social and cultural change.
505. TOPICS IN PRIMATE SOCIOBIOLOGY (3) An advanced seminar on current research and problems in the study of nonhuman primate behavior and ecology. Prerequisite: Anthy. 458.
506. CULTURAL DYNAMICS (3) Survey of the major theories of culture change with special reference to archaeological research.
507. THE BIOLOGY OF HUMAN ADAPTABILITY (3) An exploration of the biological mechanisms which aid man's survival in a variety of environmental settings.
508. RESEARCH PROBLEMS IN CULTURE HISTORY (3-9)
509. SEMINAR IN REGIONAL STUDIES (3-9) Research and analysis in selected world cultural areas, including ecology, prehistory, history, ethnography, and current status.
510. WORLD ETHNOGRAPHIC SURVEY (3) General survey of world cultures and their historical development.
511. (HI.Ed. 511) HEALTH IMPLICATIONS IN THE GROWTH AND DEVELOPMENT OF SCHOOL CHILDREN (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems.
513. (HI.Ed. 513) HEALTH IMPLICATIONS IN MATURITY AND AGING (3) Changes in the human body in maturity and aging; mechanisms of physiologic aging; implications for health and preventive medicine. Prerequisite: HI.Ed. 511.
- 522-523. ECOLOGICAL THEORY IN ANTHROPOLOGY (3 each) Man's biology, culture history, and culture variation from the ecological perspective. Two-term enrollment required. Prerequisite: 6 credits in anthropology.

- 530. INDIVIDUAL READINGS IN ANTHROPOLOGY (1-6) Reading or research in selected aspects of general anthropology.
- 531. INDIVIDUAL RESEARCH IN ANTHROPOLOGY (3-12)
- 545. SEMINAR IN ANTHROPOLOGY (1-9) Critical analysis of research in selected areas of anthropology.
- 558. EVOLUTION OF SOCIAL STRUCTURES I (3) Evolution of social organization. Biological and social changes differentiating human and primate societies.
- 559. EVOLUTION OF STRUCTURES II (3) Major anthropological approaches to study of social organization.
- 560. ANTHROPOLOGICAL THEORY (3) Theory used in culture — historical, sociological, and psychological interpretations.
- 561. FIELD METHODS IN ANTHROPOLOGY (3-9) Individual field work in any aspect of anthropology, supervised by staff of professional rank.
- 562. LABORATORY METHODS IN ANTHROPOLOGY (3-9) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.
- 563. SEMINAR IN LINGUISTIC ANTHROPOLOGY (3-6) Organized research on special topics in linguistic anthropology.
- 597. SPECIAL TOPICS (1-6)

ARCHITECTURAL ENGINEERING (A E)

GIFFORD H. ALBRIGHT, *Head of the Department*
101 Engineering A Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members McLaughlin and Tichy.

Graduate Faculty: Associate Members Albright, Flynn, Geschwindner, Gilman, Summers, and Wheeler.

Students may specialize in structural analysis and design, environmental control engineering (including energy conservation and energy management in building), solar energy applications, illumination, acoustics, materials of construction, building construction management, computer application to building design and performance, or nuclear defensive and protective construction. The latter area includes shelter planning, effects of nuclear weapons, shelter environmental requirements, analysis and design of blast-resistant structural systems, and integrated engineering requirement for protective construction.

For admission a student must have a strong background in some field of engineering; in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURAL ENGINEERING (A E)

- 401. ARCHITECTURAL ENGINEERING (3)
- 402. ARCHITECTURAL ENGINEERING (3)
- 403. ARCHITECTURAL ENGINEERING (3)
- 430. ARCHITECTURAL ENGINEERING (3)

- 431. ARCHITECTURAL ENGINEERING (3)
 - 439. ARCHITECTURAL ENGINEERING (3)
 - 441. INTEGRATION OF ARCHITECTURAL ENGINEERING SYSTEMS (3)
 - 454. ENVIRONMENTAL ENGINEERING IN BUILDINGS — DESIGN (3)
 - 458. ADVANCED ARCHITECTURAL ACOUSTICS AND NOISE CONTROL (3)
 - 464. ADVANCED ARCHITECTURAL ILLUMINATION SYSTEMS DESIGN (3)
 - 471. BUILDING CONSTRUCTION ASSEMBLIES (3)
 - 472. BUILDING CONSTRUCTION MANAGEMENT I (3)
 - 473. BUILDING CONSTRUCTION MANAGEMENT II (3)
 - 474. BUILDING COST ANALYSIS (3)
 - 475. BUILDING CONSTRUCTION ENGINEERING I (3)
 - 476. BUILDING CONSTRUCTION ENGINEERING II (3)
 - 477. BUILDING PROJECT ANALYSIS (3)
 - 481. ARCHITECTURAL ENGINEERING THESIS (2)
 - 482. ARCHITECTURAL ENGINEERING THESIS (2)
 - 483. ARCHITECTURAL ENGINEERING THESIS (2)
 - 486. PROFESSIONAL ENGINEERING PRACTICE (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
542. ADVANCED PROBLEMS AND RESEARCH IN ARCHITECTURAL ENGINEERING (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems.
545. ARCHITECTURAL ENGINEERING SEMINAR (1-6) Current literature and special problems in architectural engineering; presentation of technical papers.
553. SELECTED PROBLEMS IN NUCLEAR DEFENSE RESEARCH (1-6)

ARCHITECTURE (ARCH)

RANIERO CORBELLETTI, *Head of the Department*
308 Sackett Building

Degrees Conferred: M.S., M.Arch.

Graduate Faculty: Senior Members Corbelletti, Golany, and Strumillo.

Graduate Faculty: Associate Members Anderson, Hallock, Inserra, and Vollmer.

The Master of Science is an academic degree available to students with training in other design-related fields, as well as to students with a professional degree in architecture reentering the University for study in a speciality. Advanced studies are offered in architecture, urban design, and planning. The student is offered opportunity for independent research and extensive interdisciplinary work under the guidance of specialists and scholars in technical, cultural, industrial, and social fields. The nonthesis option is available for the M.S. degree.

The Master of Architecture degree program is planned to provide the depth and breadth of knowledge needed to enter the architectural profession and become licensed as a professional architect after the required period of internship. Requirements for admission include the equivalent of 39 credits in design-research work and a statement of purpose concerning the professional aims of the candidate. A portfolio of examples of the student's work must be presented. The nonthesis option is available for the M.Arch. degree. The program is available to candidates holding a B.A. or B.S. degree with a major in architecture, or environmental design, or holding other nonprofessional degrees in architecture.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURE (ARCH)

- 430. DESIGN-RESEARCH II (4-12)
- 441. ARCHITECTURAL DESIGN ANALYSIS (3)
- 442. ARCHITECTURAL DESIGN ANALYSIS (3)
- 443. ARCHITECTURAL DESIGN ANALYSIS (3)
- 461. ARCHITECTURAL STRUCTURAL SYSTEMS I (3)
- 462. ARCHITECTURAL STRUCTURAL SYSTEMS II (3)
- 463. ARCHITECTURAL STRUCTURAL SYSTEMS III (3)
- 465. ARCHITECTURAL BUILDING MATERIALS (3)
- 471. ENVIRONMENTAL CONTROL SYSTEMS I (3)
- 472. ENVIRONMENTAL CONTROL SYSTEMS II (3)
- 481. ADVANCED ARCHITECTURAL DATA SYSTEMS I (3)
- 482. ADVANCED ARCHITECTURAL DATA SYSTEMS II (3)
- 483. SPECIAL PROBLEMS — ARCHITECTURAL DATA SYSTEMS APPLICATIONS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 515. NEW TOWNS PLANNING SEMINAR (3) Examination of the process, concepts, and structure of new towns planning as a response to contemporary urban-regional development problems.
- 516. NEW COMMUNITIES SEMINAR (3) Examination and evaluation of the new communities movement in the United States.
- 517. NEW TOWNS PLANNING PROCESS (3) A systematic study and analysis of the sequence of actions in the new towns planning process.
- 518. NEW TOWNS RESEARCH SEMINAR (3) Advanced research seminar using comparative case studies of comprehensive contemporary issues of new towns planning. Prerequisites: Arch. 515, 517.
- 530. ARCHITECTURE I (4-12) Problems in architectural planning and design. Programming and/or implementation methodologies and applications for various environmental design scales.
- 531. ARCHITECTURE II (4-12) Continuation of Arch. 530 with concentration and specialization options. Prerequisite: Arch. 530.
- 532. COMPREHENSIVE PLANNING PROCESS STUDIO (4-12) Field case studies in analysis forecasting and projections of urban physical design elements. Preparation of comprehensive plan, regulations, and implementation.
- 535. NEW TOWNS PLANNING STUDIO (4-12) A team workshop of planning and design of new towns, involving data gathering, surveys, analysis, projection, and implementation.
- 591. ARCHITECTURAL RESEARCH (2-12) Guided research project.

ART (ART)

JAMES R. SHIPLEY, *Acting Head of the Department*
102 Visual Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Members Adams, Cook, McCoy, and Zoretich.

Graduate Faculty: Associate Members DonTigny, Frost, Hessel, Lang, McHale, Porter, Shobaken, Sommese, and Stephenson.

The M.A. program is planned to provide a broad range of experience and study in the visual arts. A thesis in an area of specialization is required. Requirements for admission include a broad undergraduate training in art and the presentation of a portfolio of the applicant's work.

The M.F.A. program is planned to provide professional emphasis in a specific area of art. A creative project and supporting monograph are required. Requirements for admission include 36 credits in studio art with some indication of concentration in a chosen area and a statement of purpose concerning the professional aims of the candidate. A portfolio must be presented.

A portfolio of slides (quality photographs for sculpture applicants), rather than actual work, is requested. A selection of no fewer than twenty examples should be presented. The majority of these should be in the area of the applicant's interest, but the portfolio should also include a lesser emphasis in related areas.

All students accepted for graduate study in art who lack the adequate undergraduate courses or show deficiencies in some area will be required to take additional course work without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ART (ART)

- 411. SEMINAR IN CONTEMPORARY ART (3 per term, maximum of 6)
- 421. ADVANCED DRAWING (3 per term, maximum of 9)
- 425. DRAWING SEMINAR (3 per term, maximum of 6)
- 430. ADVANCED SCULPTURE (3 per term, maximum of 12)
- 448. ADVANCED PRINTMAKING (3 per term, maximum of 12)
- 450. ADVANCED PAINTING (3 per term, maximum of 12)
- 455. ADVANCED PAINTING CRITIQUE (3 per term, maximum of 6)
- 460. ADVANCED WATERCOLOR (3 per term, maximum of 12)
- 465. ADVANCED DESIGN (3 per term, maximum of 9)
- 470. TIME AND SEQUENCE (3)
- 471-472. SENIOR PROBLEMS (3 each)
- 473. GRAPHIC DESIGN SEMINAR (3)
- 480. ADVANCED CERAMIC ARTS (3 per term, maximum of 12)
- 491. PHOTOGRAPHY AND OTHER DISCIPLINES (3 per term, maximum of 12)
- 494. GROUP PROJECTS IN PHOTOGRAPHY (3 per term, maximum of 9)
- 495. CREATIVE PROJECTS IN PHOTOGRAPHY (3 per term, maximum of 12)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. ART RESEARCH (2-6) Original study and practice in art relating to material, concept, or technique.

- 530. ADVANCED SCULPTURE (3-12) Individual projects in sculpture leading to the development of a collection or body of work representative of the artist.

- 545. PRINTMAKING (2-12) Problems in printmaking leading to the development of a collection or body of work representative of the individual artist.

- 550. PAINTING (2-12) Individual problems in painting leading to the development of a collection or body of work representative of the artist.

- 570. DESIGN (2-12) Individual projects in design with special emphasis on professional practice in specialized fields of graphic design.

- 580. CERAMICS (2-12) Experimental problems in ceramics leading to the development of a collection or body of work representative of the individual.

- 595. PHOTOGRAPHY (3) Individual projects in photography leading to the development of a body of specialized work representative of the artist. Prerequisite: 12 credits of Art 495.

ART EDUCATION (A ED)

KENNETH R. BEITTEL, *in charge of Graduate Programs in Art Education*
268 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Beittel, Bradley, Hoffa, Schwartz, Van Dommelen, and Wilson.

Graduate Faculty: Associate Members Anderson, Chomicky, and Ott.

This program prepares students for careers in public school art teaching, art supervision, college teaching, administration, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include work in art studio, art history, art education, education, educational psychology, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctoral degree. A foreign language is not required of all Ph.D. degree candidates. In lieu of a foreign language, students will include a series of research and communications studies pertinent to their interests and to their graduate programs and may include a foreign language approved by the doctoral committee.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Transcripts should indicate high attainment in appropriate academic and creative work, and recommendations should attest to scholarship and ability to work independently. Creative work, as shown by slides and photographs, should show a high level of involvement and sensitivity to aesthetic-forming processes.

Students who seek admission to the graduate program must make formal application to the admissions committee of the art education program.

ART EDUCATION (A ED)

- 404. METHODS OF GRAPHICS AND ILLUSTRATIONS (3)
- 414. ADVANCED CRAFTS FOR TEACHERS (3-6)
- 415. FIBER CRAFTS IN EDUCATION (3)
- 417. METAL CRAFTS IN EDUCATION (3)
- 420. CERAMICS FOR TEACHERS (3)
- 434. ART APPRECIATION IN THE EDUCATIONAL PROGRAM (3)
- 435. ART IN THE ELEMENTARY SCHOOL (3)
- 436. ART IN THE SECONDARY SCHOOL (3)
- 437. PROFESSIONAL TERM IN ART EDUCATION (10)
- 486. CURRENT PROBLEMS IN ART EDUCATION (2-3)
- 487. MURAL PAINTING IN SCHOOLS (3)
- 488. ADVANCED MURAL PAINTING IN SCHOOLS (3)
- 489. ART EXPERIENCES WITH CHILDREN (3)
- 490. INTRODUCTION TO RESEARCH IN ART EDUCATION (3)
- 494. SCHOOLS AND MUSEUMS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501. SEMINAR IN ART EDUCATION (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.

504. ADVANCED METHOD IN GRAPHIC PROCESSES (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.

514. **FUNCTIONAL RELATIONSHIPS IN CRAFTS (3)** Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisite: 6 credits in crafts, or 3 in design and 3 in advanced crafts.
516. **ANALYSIS OF THREE-DIMENSIONAL PROCESSES IN ART (3)** Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.
520. **ADVANCED CERAMIC ART (3)** Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A.Ed. 420.
535. **ADMINISTRATION AND SUPERVISION OF ART EDUCATION PROGRAMS (3)** The problems and responsibilities of the city, county, and state art supervisor; curriculum, facilities, financing, supervision, in-service training, and reporting. Prerequisites: A.Ed. 435, 436.
536. **CURRICULUM DEVELOPMENT IN ART EDUCATION (3)** Factors affecting art curriculum decisions, analysis, selection, organization, preparation of curriculum. Evaluation and sources of art curriculum improvement and innovation. Prerequisite: 6 credits of methods.
541. **THEORIES OF CHILD ART (3)** Study of current theories of child art; application of recent psychological and anthropological theories to understanding child art. Prerequisite: A.Ed. 486 or 501.
545. **EVALUATION AND ASSESSMENT IN ART EDUCATION (3)** Study of theories of evaluation; application of judgmental criteria; analysis and construction of assessment instruments and scoring procedures. Prerequisites: A.Ed. 490, 501.
588. **HISTORY OF ART EDUCATION (3)** Historical development of philosophies in art education in the United States and abroad.
589. **RESEARCH METHODS IN ART EDUCATION (3-6)** Orientation in research methods; findings and designs related to the study of problems in art education.
595. **RESEARCH IN ART EDUCATION (1-6)** Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisite: 15 credits in art education at the 400 and 500 levels, including A.Ed. 589.
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

ART HISTORY (ART H)

HELLMUT W. HAGER, *Head of the Department*
229 Arts II Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Battisti, Chenault Porter, Cutler, Davezac, Fleischer, Hager, Henisch, Kiang, and Maurer.

Graduate work is offered in the following areas: ancient art, medieval and Byzantine art, Renaissance and baroque art, and modern art. Special research opportunities are available through the Center for the Study of Renaissance and Baroque Art.

Candidates for the M.A. degree are required to complete a master's thesis and to demonstrate a reading knowledge of two foreign languages, one of which must be German. The other language is normally French or Italian. Reading knowledge of one of these languages must be demonstrated before the end of four terms of study. These regulations apply equally to Ph.D. students. For those students wishing to enter the doctoral program who have already completed a master's degree from another university, a reading knowledge of one foreign language will be required before the student can be considered for admission to the department.

Candidates with a 3.00 junior-senior grade-point average and a minimum of 21 credits in art history will be considered for admission to the master's program. Lacking these, a promising candidate may be accepted on condition that deficiencies be remedied, but without graduate degree credit. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

ART HISTORY (ART H)

401. STUDIES IN GREEK ART (3)
 402. THE ILLUMINATED MANUSCRIPT (3)
 404. THE ART OF COLONIAL AMERICA (3)
 405. PIONEERS OF MODERN ARCHITECTURE (3-6)
 410. TASTE AND CRITICISM IN ART (3)
 411. ART OF IMPERIAL ROME (3)
 412. THE GOTHIC CATHEDRAL (3)
 414. STUDIES IN ITALIAN BAROQUE ART (3-9)
 415. THE SKYSCRAPER (3)
 416. AMERICAN PAINTING: 1876-1913 (3)
 422. STUDIES IN MEDIEVAL SCULPTURE (3)
 423. STUDIES IN ITALIAN RENAISSANCE ART (3-9)
 424. MASTERS OF NORTHERN BAROQUE ART (3)
 425. MOVEMENTS IN NINETEENTH-CENTURY ART (3)
 430. GOYA AND HIS TIMES (3)
 432. PROBLEMS IN ICONOLOGY (3)
 435. MOVEMENTS IN TWENTIETH-CENTURY ART (3-6)
 443. PROBLEMS IN BYZANTINE ART (3)
 450. THE HISTORY OF PHOTOGRAPHY (3)
 451. SURVEY OF SPANISH BAROQUE PAINTING (3)
 452. PAINTING IN THE AGE OF LOUIS XIV (3)
 456. GIAN LORENZO BERNINI AND THE ARCHITECTURE OF THE FULL BAROQUE IN ROME (3)
 458. ROMAN ROCOCO ARCHITECTURE AND THE DAWN OF NEOCLASSICISM (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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510. STUDIES IN ART HISTORY (3-6 per term) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.
 511. SEMINAR IN ANCIENT ART (3-12) Selected topics from the history of Greek and Roman art.
 512. SEMINAR IN MEDIEVAL ART (3-12) Original research into problems dealing with the art of the Middle Ages.
 513. SEMINAR IN RENAISSANCE ART (3-12) Investigations in the area of Renaissance art, centering around major masters and monuments.
 514. SEMINAR IN BAROQUE ART (3-12) Investigations in the area of baroque art, centering around major masters and monuments.
 515. SEMINAR IN MODERN ART (3-12) Lectures, readings, reports, and discussions in the field of modern art.
 517. SEMINAR IN EIGHTEENTH-CENTURY ART (3-12) Investigation into themes and problems dealing with eighteenth-century art.
 520. SEMINAR IN SPANISH BAROQUE PAINTING (1-6) Specific problems in the history of seventeenth-century Spanish painting.
 522. SEMINAR IN BYZANTINE ART (3-12) Specific iconographical and stylistic problems in Byzantine art and its relation to classical antiquity, the medieval West, and Islam.
 525. SEMINAR IN MODERN ARCHITECTURE (3-12) Investigation into the works and problems of modern architecture as they relate to the culture of our times.
 542. THE ILLUSTRATION OF THE APOCALYPSE (3-6) Studies in the illustration of the Apocalypse, iconographical and stylistic, from the early Christian period through Dürer.
 551. HISTORIOGRAPHY OF ART HISTORY (1-6) The relationship between the definition of, and approach to, art-historical problems from Vasari to the present.

552. **PROBLEMS IN CONNOISSEURSHIP (3)** A study of the problems of authenticating, attributing, and dating paintings and sculpture through internal evidence.

555. **ART HISTORY FIELD SEMINAR (3-12)** Investigations based on the site study of specific art objects, with trips in successive years to different art centers.

ASTRONOMY (ASTRO)

SATOSHI MATSUSHIMA, *Head of the Department*
525 Davey Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Matsushima, Sampson, Usher, and Weedman.

Graduate Faculty: Associate Members Panek, Ramsey, Winkler, and Zabriskie.

Graduate instruction and research opportunities are available in both observational and theoretical astronomy and astrophysics. The areas of current research interest include: atomic processes and radiative transfer, theory of stellar and planetary atmospheres, stellar structure and pulsation theory, gaseous nebulae and interstellar matter, quasi-stellar objects and variable galaxies, solar physics, objects in the solar system, eclipsing binaries and binary star systems, cosmology, astrophysical photometry and spectroscopy, and astronomical instrumentation. Opportunities for thesis research also are offered, in cooperation with other departments, in plasma and high-energy astrophysics, nucleosynthesis, and relativity.

Research facilities include a new observatory near the Black Moshannon State Park, located 25 miles north of the University Park Campus, which is equipped with telescopes of 152 cm and 61 cm aperture with instrumentation for spectroscopic and photometric observations.

Modern astronomy has very close ties with mathematics, physics, and engineering. The program required of a doctoral candidate would normally include courses in at least two of these related fields, in addition to those in astronomy. Two of three foreign languages chosen from French, German, or Russian are required. A knowledge of computer programming may be substituted for one of the two foreign languages required. The nonthesis option is available for the M.S. degree.

Applicants with a bachelor's degree in astronomy or an allied field such as physics, mathematics, or geophysics are given equal consideration for admission. Opportunity to make up possible undergraduate deficiencies is provided. A grade-point average of 3.00 or better for junior-senior courses in astronomy and related subjects is necessary for consideration for admission, although exceptions to this minimum requirement may be made for students with special backgrounds, abilities, and interests.

ASTRONOMY (ASTRO)

430. **GENERAL ASTRONOMY FOR TEACHERS (3)**

460. **FUNDAMENTALS OF CELESTIAL MECHANICS (3)**

470. **SOLAR PHYSICS (3)**

480. **NEBULAE, GALAXIES, AND COSMOLOGY (3)**

490. **INTRODUCTION TO ASTROPHYSICS (3)**

492. **(E.E. 492) SPACE ASTRONOMY AND INTRODUCTION TO SPACE SCIENCE (3)**

495. **PRACTICAL ASTRONOMY (3)**

496. **INDEPENDENT STUDIES (1-12)**

497. **SPECIAL TOPICS (1-6)**

510. **ASTROPHYSICS (3)** An introduction to astrophysics in which the relevant physics, spectra, gas laws, plasmas, and radiation transfer theory are discussed.

511. **ASTROPHYSICS (3)** Stellar atmospheres; considerable emphasis is placed on the sun and on solar-terrestrial relationships. Prerequisite: Astro. 510.

513. **OBSERVATIONAL TECHNIQUES IN ASTRONOMY (3)** Radiation quantities in theory and as observed. Astrometry, photometry, spectroscopy, stellar classification, interferometric methods. Observational laboratory. Prerequisite: Astro. 511.
514. **OBSERVATIONAL PRACTICE (1-3)** Practice of the use of research instruments, data acquisition, and reduction at the optical or radio observatory sites. Prerequisite: Astro. 511 or 513.
524. **CELESTIAL MECHANICS AND SPHERICAL ASTRONOMY (3)** Two-body and one-body theory, elliptic motion, expansions, two-body orbit in space, coordinate transformations, planetary equations. Lagrange and Hamilton mechanics. Prerequisites: Math. 452, Phys. 419.
530. **THEORY OF STELLAR ATMOSPHERES (3)** Theory of photospheric structure, radiative processes, and line-formation in the outer layers of stars, and interpretation of stellar spectra. Prerequisite: Astro. 511.
531. **THEORY AND ANALYSIS OF SPECTRAL LINES (3)** The formation of spectral lines for both the LTE and NLTE cases, analysis of both line profiles and integrated intensities. Prerequisite: Astro. 530.
534. **STELLAR STRUCTURE AND EVOLUTION (3)** Theory of physical processes, structure, and evolutionary changes of stars; nature of intrinsic variable stars; the Hertzsprung-Russell diagram. Prerequisite: Astro. 510 or Phys. 561.
542. **GASEOUS NEBULAE AND INTERSTELLAR MATTER (3)** Theory and observations of galactic nebulae and interstellar medium, and problems related to the formation of stars and galactic structure. Prerequisite: Astro. 511.
582. **RADIO ASTRONOMY (3)** Radiometers and antennas; signals in noise; solar physics; quiet and active solar radiation; transfer equation and solar radiation; solar-terrestrial effects. Prerequisite: E.E. 438 or Phys. 467.
583. **GALAXIES, QUASARS, AND COSMOLOGY (3)** Structure and population of the Milky Way galaxy, properties of galaxies, properties and nature of Quasars, distance scale and deceleration parameter. Prerequisite: Astro. 582.
590. **COLLOQUIUM (1-3)** Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

BIOCHEMISTRY (BIOCH)

M. FRANK MALLETTE, *In Charge of Graduate Programs in Biochemistry*
206 Althouse Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aronson, Bernlohr, Deering, Hamnerstedt, Hymer, W. Karakawa, Mallette, McCarl, Pazur, Phillips, R. Schraer, Shigley, and Wedler.

Graduate Faculty: Associate Members Johnson and J. Karakawa.

Opportunities for research and graduate study are available in intermediary metabolism, cellular control mechanisms, molecular genetics, enzyme structure, enzyme kinetics and mechanisms, proteins, carbohydrates, lipids, endocrinology, subcellular structures, computer applications, biochemistry of reproduction, heart cell culture, and immunochemistry.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of one foreign language which is widely used by biochemists.

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathe-

matics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are not required for admission.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOCHEMISTRY (BIOCH)

- 401. GENERAL BIOCHEMISTRY (3)
- 402. GENERAL BIOCHEMISTRY (3)
- 403. EXPERIMENTAL BIOCHEMISTRY (3)
- 417. BIOCHEMICAL METHODS (4)
- 425. INTRODUCTORY PHYSICAL BIOCHEMISTRY (4)
- 437. PHYSIOLOGICAL BIOCHEMISTRY (3)
- 438. PHYSIOLOGICAL METHODS (2)
- 451. SENIOR SEMINAR (1)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 503. BIOCHEMICAL PROBLEMS (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor.
- 507. SEMINAR IN BIOCHEMISTRY (1 per term)
- 514. (Bphys. 514) MOLECULAR BIOLOGY AND CELLULAR REGULATION (3) Structure, synthesis, and biochemical properties of nucleic acids; protein biosynthesis; control of gene expression; molecular genetics. Prerequisite: Bioch. 402.
- 520. CARBOHYDRATES, LIPIDS, AND THEIR INTEGRATED METABOLISM (3) Chemistry of carbohydrates, lipids, and membranes; interrelationships between lipid and carbohydrate biosynthesis and metabolism. Prerequisite: Bioch. 402.
- 525. PROTEINS AND ENZYMES (3) Properties of proteins and polypeptides, structural analysis and molecular interactions; enzyme structure, kinetic mechanisms, and control. Prerequisite: Bioch. 402.
- 590. COLLOQUIUM (1-3)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

BIOENGINEERING (BIOE)

D. B. GESELOWITZ, *Chairman of the Program Committee in Bioengineering*
328 Hammond Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Adams, Anthony, Brickman, Buskirk, Fonash, Geselowitz, Hollis, Jacobs, Kenney, Kline, Michael, Morrow, Munger, Park, Phillips, Pierce, Sharma, Ultman, Weidner, and Zelis.

Graduate Faculty: Associate Members Liedtke, and Nellis.

This intercollege program is designed to provide the student with graduate-level training in engineering and in the life sciences, and specialized training in specific areas of interaction of engineering with biology and medicine. Graduate instruction in bioengineering is under the direction of a program committee composed of Graduate Faculty representing several departments.

Opportunities for specialized research include electrical and mechanical properties of biological materials, development of an artificial heart, hemodynamics, electrocardiography, applications to nuclear medicine and radiology, biomaterials, lung mechanics, bioinstrumentation, transducers, rheology of biological fluids, and neurophysiology of vision.

The particular course of study depends on the student's background and area of research specialization. Courses are selected from the life sciences, engineering, and bioengineering. Candidates for the Ph.D. degree generally are expected to complete Phsio. (Biol.) 571-573 plus several additional courses in the life sciences, five courses in bioengineering, and five graduate-level courses in engineering, mathematics, and physics. Supporting courses are available at University Park and The Milton S. Hershey Medical Center in acoustics, anatomy, biochemistry, biology, biophysics, chemistry, laboratory animal medicine, materials science, mathematics, physiology, polymer science, psychology, and the engineering departments.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by demonstrating intermediate knowledge of an acceptable foreign language, or by taking an advanced technical writing course and presenting a formal proposal for thesis research to the doctoral committee.

A thesis is required for the M.S. degree. Course requirements include Bioe. 401 and 402 plus two 500-level courses in bioengineering, 6 credits in the life sciences including Biol. 472, and 6 credits in technically oriented courses outside of bioengineering and the life sciences. In addition, students without a previous degree in engineering or physics would be expected to complete the equivalent of the following courses during the first year: E.E. 103 and 340, E.Mch. 111 and 112, Aersp. 308.

Students with a degree in engineering, physics, or the life sciences will be eligible for admission. All students must have a strong background in physics and mathematics. This background should include 9 credits in chemistry, 9 credits in physics, mathematics through calculus and differential equations, and a course in linear systems analysis. Students who lack one or two courses may still be considered for admission but will have to make up any deficiency early in their graduate program. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOENGINEERING (BIOE)

- 401. INTRODUCTION TO BIOENGINEERING (3)
- 402. BIOMEDICAL INSTRUMENTATION AND MEASUREMENTS (3)
- 425. (Nuc.E. 425) RADIOGRAPHIC IMAGING (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. BIOENGINEERING TRANSPORT PHENOMENA (3) Application of the equations of mass, energy, and momentum conservation to physiological phenomena and to the design of artificial organs.
- 502. INTRODUCTION TO BIOELECTRIC PHENOMENA (3) Electric phenomena in nerve and muscle, membrane potentials, Hodgkin-Huxley equations, volume conductor problem, applications to electrocardiography, electroencephalography, plethysmography.
- 503. FLUID MECHANICS OF BIOENGINEERING SYSTEMS (3) Cardiovascular system and blood flow, non-newtonian fluid description, vessel flows, unsteady flows and wave motion, windkessel theory, transmission line theory.
- 504. PHYSIOLOGICAL SYSTEMS ANALYSIS (3) Application of systems theory, control theory, and analytic modeling strategies to the study of physiological systems. Prerequisites: Biol. 472, Engr. 100.
- 505. BIOENGINEERING MECHANICS (3) Passive and active mechanical properties of tissues, rheological materials, models of muscle contraction, pulmonary mechanics, forces in muscular-skeletal system.
- 570. TOPICS IN BIOMEDICAL INSTRUMENTATION (1) Physiological basis, theory of operation, and practical aspects of clinical instrumentation.
- 580. BIOENGINEERING INTERNSHIP (3-6) Supervised experience at The Milton S. Hershey Medical Center including rotation through services and work on a minor project. Prerequisites: Bioe. 402 and 3 credits in bioengineering at the 500 level.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

BIOLOGICAL CHEMISTRY (BCHEM)

EUGENE A. DAVIDSON, *Chairman of the Department*,
The Milton S. Hershey Medical Center
Hershey, PA 17033

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Davidson, Hass, Hill, McPherson, Miljkovic, Rosenberg, Schengrund, and Shiman.

Graduate Faculty: Associate Members Bhavanandan and Campbell Smith.

Opportunities for research and graduate study are available in the chemistry and metabolism of complex polysaccharides, cellular differentiation, mechanism of enzymatic reactions, biochemical genetics, biochemistry of complex lipids, conformational analysis of carbohydrates and proteins, natural product chemistry, and physical chemistry of macromolecules.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. The nonthesis option is available for the M.S. degree.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Interested students should contact the department chairman.

The program is offered only at The Milton S. Hershey Medical Center.

BIOLOGICAL CHEMISTRY (BCHEM)

502. BIOLOGICAL CHEMISTRY I (3) Structure-function relationships of macromolecules; pathways utilized for energy generation in mammalian systems; concepts of metabolic regulation.

503. NUCLEIC ACID BIOCHEMISTRY (2) Aspects of the mechanism and control of nucleic acid and protein biosynthesis with emphasis on their relationship to genetic phenomena. Prerequisite: Microb. 556.

504. BIOLOGICAL CHEMISTRY LABORATORY (2) Laboratory exercises in biological chemistry related primarily to mammalian systems. Experience with a range of contemporary techniques. Prerequisite or concurrent: B.Chem. 502.

505. BIOLOGICAL CHEMISTRY II (3) A continuation of B.Chem. 502. Emphasis on interrelations of metabolic pathways, catabolic end products, and regulation. Prerequisite: B.Chem. 502.

513. BIOLOGICAL CHEMISTRY, MACROMOLECULES (3) Physical chemistry of macromolecules; techniques for investigating conformations, size, and interactions. Development and application of thermodynamics to solutions of macromolecules.

523. METABOLISM (3) Molecular mechanisms employed by living systems to transform biological compounds, control production and utilization of energy, and regulate metabolic pathways.

551. KINETICS AND MECHANISM OF ENZYME ACTION (3) Current kinetic theory, rapid reactions, regulatory enzymes, chemical and physical approaches to the study of the mechanism of enzyme action. Prerequisite: B.Chem. 502. Concurrent: B.Chem. 523.

553. BIOCHEMICAL TECHNIQUES (3) Lectures and discussion on approaches to macromolecule and lipid separation and characterization; isolation of subcellular organelles; enzymatic assay; radioisotopes. Prerequisite: B.Chem. 502.

- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

BIOLOGY (BIOL)

E. S. LINDSTROM, *Head of the Department*
208 Erwin W. Mueller Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cooper, Dunson, Fergus, Graves, Grove, Grun, Hamilton, Hibbard, Hillson, Hollis, Keener, MacCluer, Pursell, Schein, Spackman, Therrien, Traverse, Wickersham, Williams, Witham, and Wright.

Graduate Faculty: Associate Members Arnold, Beatty, Burris, Mitchell, Neff, Pearson, Petters, Reimer, Rheuben, Stephenson, and Turpen.

The department will direct graduate programs in behavior, cell biology, cytology, cytochemistry, environmental science, ultrastructure, and other aspects of modern biology. The courses of study are planned individually by the student and an adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. Candidates have the option of a thesis or a paper for the M.S. degree.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide scores from the Graduate Record Examination, a personal statement of interests and objectives, and letters from two persons verifying the applicant's academic competence.

BIOLOGY (BIOL)

- 402. VERTEBRATE NEUROANATOMY (3)
- 407. PLANT ANATOMY (3)
- 409. BIOLOGY OF AGING (3)
- 414. ADVANCED SYSTEMATIC BOTANY (3)
- 417. INVERTEBRATE ZOOLOGY (4)
- 418. MYCOLOGY (3)
- 420. (Geosc. 420) PALEOBOTANY (3)
- 421. COMPARATIVE ANATOMY OF VERTEBRATES (4)
- 422. ADVANCED GENETICS (3)
- 423. (Geosc. 423) INTRODUCTORY PALYNOLOGY (3)
- 426. INTRODUCTORY CYTOGENETICS (3)
- 427. (Geosc. 427) EVOLUTION (3)
- 428. POPULATION GENETICS (3)
- 429. DEVELOPMENTAL GENETICS (3)
- 431. COMPARATIVE PLANT MORPHOLOGY (2)
- 432. LABORATORY IN COMPARATIVE PLANT MORPHOLOGY (2)
- 433. TERRESTRIAL ECOLOGY (3)
- 434. TERRESTRIAL ECOLOGY LABORATORY (2)
- 435. ECOLOGY OF LAKES AND STREAMS (3)
- 436. FRESHWATER ECOLOGY RESEARCH TECHNIQUES (3)
- 437. HISTOLOGY (4)
- 438. ORNITHOLOGY (2)
- 439. ORNITHOLOGY LABORATORY (1)
- 440. EMBRYOLOGY (4)
- 441. PLANT PHYSIOLOGY (3)

442. PLANT PHYSIOLOGY (3)
 445. PHYTOHORMONES (3)
 451. PLANT SYNECOLOGY (3)
 452. ICHTHYOLOGY (3)
 454. HERPETOLOGY (2)
 460. EMBRYONIC DIFFERENTIATION (3)
 462. (Pty.Sc. 462) ANIMAL BEHAVIOR — ETHOLOGY (3)
 463. (Pty.Sc. 463, Psy. 463) ANIMAL BEHAVIOR LABORATORY (1-2)
 465. GENERAL CYTOLOGY (3)
 466. LABORATORY IN CYTOLOGY (1)
 472. VERTEBRATE PHYSIOLOGY (3)
 473. LABORATORY IN VERTEBRATE PHYSIOLOGY (2)
 476. PHYSIOLOGY OF PULMONARY RESPIRATION (2)
 477. BIOLOGY OF HUMAN SEXUALITY (3)
 478. BIOLOGICAL AND MEDICAL ASPECTS OF THE MAMMARY GLAND (2)
 479. GENERAL ENDOCRINOLOGY (3)
 481. AQUATIC BOTANY (3)
 482. COASTAL BIOLOGY (4)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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502. THE PHYSIOLOGY OF THE FUNGI (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years.
 504. (Bphys. 504) SEMINAR IN CELL BIOLOGY (1) Discussion of current problems and ideas in cell biology with emphasis on reference to recent literature.
 506. COMPARATIVE ANATOMY OF VASCULAR PLANTS (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Biol. 407. Spring term, even years.
 511. ADVANCED PLANT PHYSIOLOGY (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration and catabolism. Prerequisite: Biol. 442. Fall term.
 512. ADVANCED PLANT PHYSIOLOGY (3) Continuation of Biol. 511. Physiology of plants including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: Biol. 442. Winter term.
 516. ECOLOGICAL PLANT GEOGRAPHY (3) Distribution of plant communities; environmental factors which influence their present distribution; geological-historical development of plant communities, their past distribution. Winter term, odd years.
 517. FISH BEHAVIOR AS RELATED TO AQUATIC ECOLOGY (3) Receptor-effector systems, selection of habitat and the effects of behavioral interaction on population levels, growth and survival. Prerequisite: Biol. 452 or 462.
 518. SPECIAL PROBLEMS (1-6) Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.
 519. ZOOGEOGRAPHY (3) The present distribution of world vertebrates, their evolution, and their patterns of dispersal in the past.
 522. LOWER FUNGI (3) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Biol. 418. Winter term, even years.
 523. HIGHER FUNGI (3) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Biol. 418. Spring term, even years.
 524. SEMINAR IN GENETICS (1 per term)
 526. (Geol. 526) PROBLEMS IN PALYNOLOGY (1-6) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history.

531. BRYOLOGY (3) Morphology, taxonomy, and ecology of liverworts, hornworts, and mosses; collection, preservation, culturing, and cytologic techniques. Spring term, even years.
533. PROBLEMS IN GENETICS (2-6) Problems to suit needs of individual students; conferences and laboratory work.
535. MORPHOLOGY OF THE TRACHEOPHYTA EXCLUSIVE OF ANGIOSPERMS (3) Origin, developmental tendencies, structure, and paleobotanical evidence. Winter term, odd years.
536. MORPHOLOGY OF ANGIOSPERMS (3) Floral origin and development, fertilization, embryogeny, seeds and fruit development. Prerequisite: Biol. 431.
538. PRINCIPLES OF MICROSCOPIC HISTOCHEMISTRY (2) Theoretical basis for the microscopic identification, localization, and quantitative analysis of chemical substances in tissues of organisms. Prerequisite: Biol. 437 or 465.
539. ANALYTICAL HISTOCHEMISTRY LABORATORY (2-4) Application of histochemical techniques in the microscopic analysis of tissue lipids, proteins, carbohydrates, nucleic acids and proteins. Prerequisite or concurrent: Biol. 538.
540. PHYCOLOGY (4) Comparative morphology, taxonomy, and ecology of freshwater and marine algae; culturing, collection, preservation techniques.
542. (Ent. 542) SYSTEMATICS (3) Principles and methods of classification, phylogeny and speciation; taxonomic techniques, analysis of species; causal interpretation of animal diversity.
544. PHYSIOLOGICAL ECOLOGY (3) The physiological abilities of animals to tolerate and compensate for changes in the physical and chemical nature of the environment.
545. ECOSYSTEM DYNAMICS (3) Survey and discussion of recent literature on ecosystem structure and function. Prerequisite: Biol. 210.
546. ECOLOGY OF POPULATION AND COMMUNITIES (3) Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term.
547. INVERTEBRATE BIOLOGY (3) Embryological development, metamorphosis, regeneration, and endocrinology of selected invertebrate groups (insects excluded). Invertebrate interactions and ecological impact.
550. NEUROGENESIS (2) Embryonic and evolutionary development of the nervous system. Determination, differentiation, orientation, and specificity of growing and regenerating nerve cells. Prerequisite: Biol. 440.
557. (Sci.Ed. 557) WORKSHOPS IN THE BIOLOGICAL SCIENCES (3) Projects designed for teachers of biology in the secondary schools. Summer term only.
571. (Phsio. 571) ANIMAL PHYSIOLOGY (2) Mammalian cardiovascular system; mammalian neurophysiology; excitable tissue, sensory systems, motor systems, and autonomic system. Prerequisite: Biol. 472.
572. (Phsio. 572) ANIMAL PHYSIOLOGY (2) Mechanisms involved in the activity and control of gastrointestinal function, respiration, and renal regulation of blood and body fluids. Prerequisite: Biol. 472.
573. (Phsio. 573) ANIMAL PHYSIOLOGY (2) Hypothalamic-hypophyseal relationships. Reproductive cycle regulation, endocrine control of fluid balance, body temperature, energy homeostasis, and metabolism of protein and minerals. Prerequisite: Biol. 472.
582. (Pty.Sc. 582, Psy. 582) RESEARCH IN ANIMAL BEHAVIOR (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.
585. (Bphys. 585) BIOLOGICAL ULTRASTRUCTURE (4) The application of electron microscopy to the study of cell biology. Prerequisite: Bphys. 473 or Biol. 437 or 465 or Micrb. 401.

BIOPHYSICS (BPHYS)

REGINALD A. DEERING, *In Charge of Graduate Programs in Biophysics*
618 Erwin W. Mueller Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Deering, Hymer, Keith, Morgan, Person, H. Schraer, Smyth, Snipes, Strother, Taylor, and Todd.

The major goal of this program is to train students for independent research and teaching in the interdisciplinary areas of biophysics and molecular biology. The students currently in the department have come from a variety of fields including physics, engineering, chemistry, biochemistry, and biology. Graduate students are expected to begin a research program during their first year of study. Personal attention is given by a faculty adviser to insure that the program is suited to the student's talents and is one that will permit the earning of a degree in a reasonable time. Course requirements are flexible and depend to a considerable extent on the student's research interests. The master's program is expected to take from six to eight terms (four terms per year), and the Ph.D. usually requires an additional eight to twelve terms, including thesis research. Advancement to Ph.D. candidacy is decided on the basis of course and research performance in addition to a written examination. A comprehensive oral examination and thesis defense are integral parts of the Ph.D. program. Knowledge of a foreign language may be required depending on the area of research.

Research interests include radiation biology and DNA repair, cell biology, molecular biology and genetics, electrophysiology, structure and function of biological membranes, molecular virology, developmental biology, biophysical chemistry, pituitary cell physiology, cytofluorometry, electron microscopy, and chemical carcinogenesis.

BIOPHYSICS (BPHYS)

- 415. STRUCTURE OF BIOLOGICAL MACROMOLECULES (2)
- 430. MOLECULAR BIOLOGY OF THE GENE (3)
- 440. STRUCTURE AND FUNCTION OF BIOLOGICAL MEMBRANES (3)
- 473. MOLECULAR BIOPHYSICS I (3)
- 474. MOLECULAR BIOPHYSICS II (3)
- 475. INTRODUCTORY RADIATION BIOPHYSICS (3)
- 476. NEUROPHYSIOLOGY (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 503. BIOPHYSICS OF MEMORY (2) Molecular biology, pharmacology and physiology of learning, memory formation and recall. Reading and discussion of the pertinent current literature. Prerequisite: Bioch. 401 or Bphys. 475.
- 504. (Biol. 504) SEMINAR IN CELL BIOLOGY (1) Discussion of current problems and ideas in cell biology with emphasis on reference to recent literature.
- 514. MOLECULAR BIOLOGY AND CELLULAR REGULATION (3) Structure, synthesis, and biochemical properties of nucleic acids; protein biosynthesis; control of gene expression; molecular genetics. Prerequisite: Bioch. 402.
- 585. (Biol. 585) BIOLOGICAL ULTRASTRUCTURE (4) The application of electron microscopy to the study of cell biology. Prerequisite: Bphys. 473 or Biol. 437 or 465 or Micrb. 401.
- 587. ULTRACENTRIFUGATION (2) A laboratory course in ultracentrifugation techniques including applications to biophysical problems. Prerequisite: Bphys. 474.
- 588. PHYSIOLOGY OF NERVES, MUSCLES, AND SENSE ORGANS (2-6) Current literature of the function of nerves, muscles, and receptors. These subjects are considered individually in successive years. Prerequisite: a 400-level course in physiology, biophysics, or physiological psychology.

589. **MAMMALIAN CELL CULTURE (3)** Recent research in quantitative cell biology as studied with tissues and cells of higher organisms cultured *in vitro*. Prerequisite: Bioch. 401.

590. **COLLOQUIUM (1-3)**

595. **ELECTRON SPIN RESONANCE SPECTROSCOPY (3)** Experimental and theoretical aspects of electron spin resonance spectroscopy to provide ability for its application to biophysical problems. Prerequisite: basic knowledge of quantum mechanics and electromagnetic waves.

597. **SPECIAL TOPICS (1-6)**

BOTANY (BOT)

E. S. LINDSTROM, *Head of the Department of Biology*
208 Erwin W. Mueller Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Fergus, Grove, Grun, Hamilton, Hillson, Keener, Pursell, Schein, Spackman, Therrien, Traverse, Witham, and Wright.

Botanical programs are offered in plant anatomy, bryology, cytology, ecology, genetics, morphology, mycology, paleobotany, palynology, physiology, and taxonomy. A student having a degree in science or in one of the biological sciences is eligible for admission. Entering graduate students should have had basic courses in chemistry, mathematics, and physics. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide scores from the Graduate Record Examination, a personal statement of interests and objectives, and letters from two persons verifying the applicant's academic competence.

See also Genetics and Physiology.

NOTE: *For courses in Botany and related subjects see Biology.*

BUSINESS ADMINISTRATION (B A)

MICHAEL P. HOTTENSTEIN, *Director of the M.B.A. Program*
JOHN D. DANIELS, *Director of the M.S. and Ph.D. Programs*
101 Business Administration Building

Degrees Conferred: Ph.D., M.S., M.B.A.

Graduate Faculty: Senior Members Aggarwal, Bear, Beik, Bennett, Bither, Bradley, Carroll, Coyle, Curley, Daniels, Dinkel, Durkin, Ezzell, Ferrara, Greenlaw, Hammond, Hayya, Heitmann, Hottenstein, Kelley, Kleindorfer, Kochenberger, Koot, Malcom, Olson, Pashek, Philippatos, Philips, Radebaugh, Richards, Rigby, Schrader, Sheridan, Shilling, Sims, Spychalski, Susman, Thies, and D. Wilson.

Graduate Faculty: Associate Members Bluedorn, Dirsmith, Eyerly, Gouldey, Henszey, Holman, Jablonsky, Koehler, Lantz, Luszt, Luzi, Marlow, McCormack, Melander, Miller, Millman, Myers, Nelson, Phalan, Pitts, Raju, Rao, Reutzel, Shapiro, Snow, Stenger, Teichman, Tretter, Twark, Tyworth, VanLandingham, Watson, Williams, and R. Wilson.

The Master of Business Administration is a professional degree program in business administration designed to prepare individuals for managerial positions in business, as well as government and other nonprofit institutions. Individuals of all undergraduate disciplines, both business and nonbusiness, are encouraged to apply. This program consists of two distinct portions: (1) 3 credits each in undergraduate accounting, statistics, and economics (not exclusively macroeconomics). These prerequisite

courses may be taken as part of an undergraduate curriculum or at the University prior to starting graduate-level studies; (2) 48 credits of graduate courses and a professional paper.

Graduate-level work on the M.B.A. degree may be started fall term only. The time required to complete the graduate program, based on full-time study, is fifteen months. The student body is divided into diverse sections of approximately forty students, with each section proceeding through the same core classes. Emphasis is placed on student interaction and shared learning both inside and outside the classroom.

The M.S. and Ph.D. programs with a major in business administration are designed for those interested primarily in research and teaching. The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of two foreign languages or a reading, listening, and speaking knowledge of one language. The candidate may substitute quantitative analysis and/or behavioral science for the required reading knowledge in one or two languages. A student has an option of a thesis or a paper for the M.S. degree.

For admission to the M.S. program, approximately 33 acceptable undergraduate credits in business administration, economics, and mathematics are required. An applicant may be admitted without foundation courses, but they must be made up without degree credit. Applicants are evaluated for admission on the basis of academic potential and other factors giving evidence of high probability of completing the program. Data useful for evaluating academic potential include the applicant's professional and academic accomplishments, the Graduate Management Admission Test (GMAT) scores, and recommendations. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Applicants to any of the graduate programs in business administration are required to take the Graduate Management Admission Test (GMAT) which is administered by the Educational Testing Service four times a year. For dates, locations, and any other information on the test, write for the *Bulletin of Information*, Graduate Management Admission Test, Educational Testing Service, Princeton, New Jersey 08540.

This graduate program is accredited by the American Association of Collegiate Schools of Business.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

ACCOUNTING (ACCTG)

- 401. ADVANCED ACCOUNTING (3)
 - 403. AUDITING (3)
 - 404. MANAGERIAL ACCOUNTING (3)
 - 406. ADVANCED FEDERAL TAXATION (3)
 - 409. ACCOUNTING INFORMATION SYSTEMS (3)
 - 413. AUDITING INTERNSHIP (3)
 - 414. MANAGERIAL ACCOUNTING INTERNSHIP (3)
 - 421. INTERNATIONAL ACCOUNTING (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
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- 501. RESEARCH METHODS IN ACCOUNTING (3) An introduction to the methods and techniques of contemporary research in accounting. Prerequisites: Acctg. 504, 507, and a course in statistical inference.
 - 503. SEMINAR IN AUDITING (3) The attest function of independent public accountants, verification of financial statements; problems of evidence, independence, ethics, professional responsibilities. Prerequisite: Acctg. 403.
 - 504. SEMINAR IN MANAGERIAL ACCOUNTING (3-6) Accounting and the managerial processes of planning, control, and decision making.
 - 507. SEMINAR IN FINANCIAL ACCOUNTING (3) Theoretical basis of financial accounting.
 - 508. CONTEMPORARY ISSUES IN ACCOUNTING (3) Selected problems of current interest to the accounting profession.

- 511. FINANCIAL AND MANAGERIAL ACCOUNTING (3) Fundamental financial and managerial accounting concepts and issues from the viewpoint of the report user.
- 512. FINANCIAL ACCOUNTING THEORY AND REPORTING PROBLEMS (3) Measurement and reporting of financial information for external purposes, with particular attention to current problems in asset and income measurement. Prerequisite: Acctg. 511.
- 514. SEMINAR IN FEDERAL TAXATION (3) The federal tax structure, including legal, economic, and government implications; focusing on business decisions, research methodology, and tax planning.
- 515. DEVELOPMENT OF ACCOUNTING THOUGHT (3) Development of accounting thought from ancient civilizations to the present.
- 516. SEMINAR IN NOT-FOR-PROFIT ACCOUNTING (3) Measurement and structuring of financial information for managerial planning and control and external reporting.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2)

BUSINESS ADMINISTRATION (B A)

- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 499. FOREIGN STUDY IN BUSINESS ADMINISTRATION (2-6)
- 503. SEMINAR IN PUBLIC UTILITIES (3)
- 517. COMMUNICATION SKILLS FOR MANAGEMENT (1 per term, maximum of 3) Development of communication skills required for management; audience awareness, style, individual and group presentations. Prerequisite: admission to the Master of Business Administration Program.
- 537. (Cmp.Sc. 537) MANAGEMENT INFORMATION SYSTEMS DESIGN (3) Cost, value, and technical considerations in analysis and design of information systems whose purposes are to aid decision making in organizations.
- 538. INFORMATION SYSTEMS FOR PLANNING AND CONTROL (3) Analysis of information requirements for planning, decision making, and performance measurement in organizations.
- 539. SEMINAR IN MANAGEMENT INFORMATION SYSTEMS (3) Special topics selected from contemporary issues in management information systems.
- 550. BEHAVIORAL SCIENCE IN BUSINESS (3) Application of behavioral science concepts and analytical methods to problems in business organizations. Analysis of administrative behavior and decision making.
- 555. BUSINESS AND SOCIETY (3) Evolution of the business organization and the changing framework of its operations, responsibilities, and social control.
- 560. ENTERPRISE CONSULTING (3) Student groups engaging in consulting relationships with enterprises through use of managerial techniques for identification, analysis, and solution of managerial problems. Prerequisites: Acctg. 511; B.A. 550, 555; Econ. 500; Q.B.A. 510 and 521.
- 574. BUSINESS RESEARCH (1-3) A project paper, comparable in quality and scope of work to a graduate thesis, on problems of a company. Prerequisite: 15 credits of 400- and 500-level courses in business administration.
- 577. ADMINISTRATIVE INTEGRATION (3) An analysis of coordination of the functional areas of business in relation to overall company objectives. Prerequisite: 15 credits of 400- and 500-level courses in business administration.
- 578. ENTREPRENEURSHIP (3) Study of the development or acquisition of a business appropriate to the objectives and resources of the individual entrepreneur.

BUSINESS LAW (B LAW)

- 400. REAL ESTATE LAW (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

*398G. ACCELERATED BUSINESS LAW (3) Social control through law: courts; policies underlying individual rights; negotiable and nonnegotiable contractual rights in society. Open to graduate students only.

BUSINESS LOGISTICS (B LOG)

- 412. TRANSPORT PLANNING ANALYSIS (3)
- 420. URBAN TRANSPORTATION (3)
- 430. TRANSPORT PROBLEMS (3)
- 440. LOGISTICS SYSTEMS ANALYSIS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

538. LOGISTICS SYSTEMS MANAGEMENT (3) Control of the movement of goods; coordination of supply and demand in creation and maximization of time and place utility.

540. TRANSPORT POLICY (3) Role of transport in the economy. Transport systems elements, development, cost and pricing characteristics. Public control and public policies.

541. SOCIOECONOMIC ANALYSIS IN TRANSPORTATION (3) Role of transport in social and economic activity. Planning and coordination of transport systems. Designed for the traffic engineering program.

565. SEMINAR IN BUSINESS LOGISTICS (3-6)

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

FINANCE (FIN)

- 405. CAPITAL BUDGETING (3)
- 406. SECURITY ANALYSIS AND PORTFOLIO MANAGEMENT (3)
- 408. FINANCIAL MARKETS (3)
- 410. SPECULATIVE MARKETS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

*398G. ACCELERATED FINANCIAL MANAGEMENT (3) Financial planning and forecasting; management of working capital, capital budgeting, and dividend policy; capital structure and valuation. Open to graduate students only.

504. PROBLEMS IN FINANCE (3-6) Planned individual projects involving library, laboratory, or field work.

505. (I.B. 505) MULTINATIONAL MANAGERIAL FINANCE (3) Analysis of the international aspects of managerial finance. Emphasis on the environmental and institutional factors influencing capital acquisition and allocation. Prerequisite: Fin. 531.

506. PORTFOLIO THEORY AND POLICY (3) Rigorous examination and analysis of asset-holder behavior under conditions of risk and uncertainty.

*No graduate credit is given for this course.

508. ANALYSIS OF FINANCIAL MARKETS (3) Analysis of factors affecting price determination in financial markets.
510. CONTEMPORARY ISSUES IN FINANCIAL INSTITUTIONS (3) Critical investigation of problems of current interest in the market structure and internal operations of financial institutions.
531. FINANCIAL MANAGEMENT (3) An intensive examination of techniques available to aid the financial manager in decision making.
532. FINANCIAL DECISION PROCESSES (3) Financial decision making under uncertainty; positive and normative models and current issues in financial management.
541. SECURITY ANALYSIS (3) Discussion and application of analytical techniques in security valuation, including use of computers.
561. SEMINAR IN FINANCE (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

INSURANCE (INS)

400. ESTATE PLANNING (3)
401. FUNDAMENTALS OF PRIVATE PENSIONS (3)
410. COMPOUND INTEREST AND ANNUITIES — CERTAIN (3)
411. LIFE CONTINGENCIES I (3)
412. LIFE CONTINGENCIES II (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. INSURANCE THEORY AND PRACTICE (3) Insurance as an institution, a technique, a legal contract; its environment as a regulated industry.
504. PROBLEMS IN INSURANCE (3) Planned individual projects involving library, laboratory, or field work.
510. RISK MANAGEMENT (3) Analysis of managerial problems and responsibilities of risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.
596. INDIVIDUAL STUDIES (1-6)

INTERNATIONAL BUSINESS (I B)

501. THE INTERNATIONAL ENVIRONMENT (3) Conceptual approach analyzing and predicting influences of social, political, and economic norms and values upon diverse societies' managerial decision making.
502. INTERNATIONAL BUSINESS MACRO THEORY AND POLICY I (3) International economic trade and monetary tools are applied to current national policy issues to determine effects on international business operations. Prerequisite: Econ. 333.
503. INTERNATIONAL BUSINESS MICRO THEORY AND POLICY I (3) Analysis of the internal operations of multinational firms; design of optimal strategies of operation under varying environmental conditions.
504. SEMINAR IN INTERNATIONAL BUSINESS (3-6) Seminar in techniques applied to selected topics; market structures; capital budgeting, investment; comparisons of foreign norms and values; multinational organization characteristics.

505. (Fin. 505) MULTINATIONAL MANAGERIAL FINANCE (3) Analysis of the international aspects of managerial finance. Emphasis on the environmental and institutional factors influencing capital acquisition and allocation. Prerequisite: Fin. 531.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

MANAGEMENT (MGMT)

410. OPERATIONS PLANNING AND CONTROL (3)

420. MANAGEMENT OF PERSONNEL SYSTEMS (3)

422. ADVANCED ORGANIZATION THEORY (3)

430. ADMINISTRATIVE MANAGEMENT (3)

432. SIMULATION OF MANAGEMENT SYSTEMS (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

510. OPERATIONS MANAGEMENT (3) Integration and application of decision making to operational and policy problems within the business firm.

515. DESIGN OF OPERATION OUTPUT SYSTEMS (3) Examination of research-based findings in operations management with a focus on the design and reliability of production systems.

516. OPERATIONS PLANNING AND CONTROL (3) Examination of research-based findings in operations management. The focus is on the operation and control of production systems.

517. MANAGEMENT OF SOCIO-TECHNICAL SYSTEMS (3) Surveys the economic, psychological, and sociological issues of work quality in terms of managerial implications and change strategies.

518. MANAGEMENT OF INVENTORY SYSTEMS (3) Analysis of business organizations as integrated inventory systems. Inventory theory and model building as tools for management decision making. Prerequisite: Q.B.A. 561 or Mgmt. 510 or I.E. 509.

520. COMPLEX ORGANIZATIONS: STRUCTURE AND DESIGN (3) Analysis of theory, research, and practice in the design of complex organizations. Relationships between organizational environments and structures are emphasized.

521. ORGANIZATIONAL POWER AND CONTROL (3) Theoretical and research emphasis on the bases and consequences of power and control in complex organizations.

523. ORGANIZATIONAL CHANGE: THEORY AND PRACTICE (3) Analysis of research, theory, and practice in dynamics of organizational change. Research literature reviewed for evaluation of concepts and methods.

524. INTERPERSONAL RELATIONS IN ORGANIZATIONS (3) Development of skills and sensitivity for dealing with interpersonal relationships in complex organizations. Prerequisite: B.A. 550.

531. MANAGEMENT INFORMATION SYSTEMS (3) Information system theories and methods applied to administrative structures and management decisions in organizations.

540. PERSONNEL MANAGEMENT (3) Theory and practice of personnel management and analysis of personnel problems of relevance to all types of managers.

570. SEMINAR IN MANAGEMENT (3-6) Comparative analysis of research in the theories of the administrative sciences; relationships to business management practices.

575. FUTURE STUDIES AND MANAGERIAL PLANNING (3) Theory and research on the "future" dimensions of decision making and planning, particularly under conditions of rapid change.

576. PLANNING MODELS AND TECHNIQUES (3) Survey of models, concepts, and techniques appropriate to managerial long-range planning in complex organizations.

- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

MARKETING (MKTG)

- 422. SEMINAR: MARKETING COMMUNICATION (3)
- 424. MARKETING RESEARCH PROJECTS (3)
- 430. CONSUMER BEHAVIOR (3)
- 435. MARKETING AND PUBLIC POLICY (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

500. MARKETING MANAGEMENT (3) Analysis of management's marketing problems including market analyses, pricing, channel of distribution, promotion, competition, product strategies, and marketing research.

510. PLANNING MARKET STRATEGY AND PROGRAMS (3) Development of marketing strategy for the firm and design of integrated product-service, promotion, and distribution programs utilizing systems analysis.

520. QUANTITATIVE ANALYSIS FOR MARKETING DECISIONS (3) Sales forecasting, new product proposals, media selection, and market testing analyzed using statistical and decision theory and other mathematical techniques.

530. CONSUMER AND MARKET BEHAVIOR (3) Buying behavior: concepts from the behavioral sciences, including utility, culture, life cycle, personality, attitudes, and learning.

540. MARKETING AND SOCIETY (3) Marketing problems of society, domestic and regional marketing systems; governmental policies toward marketing; social performance of marketing.

544. MARKETING THEORY (3) The development of marketing concepts, behavioral and other marketing theories; public policy and the role of marketing in societies.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

QUANTITATIVE BUSINESS ANALYSIS (Q B A)

- 404. SAMPLING IN BUSINESS OPERATIONS AND RESEARCH (3)
- 451. LINEAR PROGRAMMING (3)
- 452. NONLINEAR PROGRAMMING (3)
- 461. PROBABILISTIC MODELS IN BUSINESS (3)
- 490. ADVANCED BUSINESS STATISTICS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

*398G. ACCELERATED BUSINESS STATISTICS (3) Basic characteristics of univariate and bivariate distributions, probability theory, introduction to estimation, tests of hypotheses, and time series analysis. Open to graduate students only.

500. SEMINAR IN BUSINESS STATISTICS (3-6)

501. ADVANCED BUSINESS STATISTICS (3)

510. STATISTICAL ANALYSIS FOR MANAGERIAL DECISION MAKING (3) Use of statistical methods for managerial decision making with emphasis on problem formulation, data analysis and interpretation, and business applications. Prerequisites: 3 credits each in undergraduate accounting, economics, and statistics.

*No graduate credit is given for this course.

521. **QUANTITATIVE ANALYSIS FOR BUSINESS DECISIONS (3)** Construction and use of quantitative methods in business decision making. Prerequisite: common requirements of M.B.A. program.
527. **ANALYSIS FOR DECISION MAKING UNDER UNCERTAINTY (3)** Topics in decision making under uncertainty including decision theory, Bayesian statistics, payoff function including utility theory and multi-attribute measures.
532. **MANAGEMENT SYSTEMS SIMULATION (3)** Application of computer simulation to the analysis and design of management decision systems. Design of simulation experiments in business research. Prerequisite: 3 credits of computer programming.
540. **MATHEMATICAL PROGRAMMING (3)** Nonlinear programming and geometric programming with emphasis on both theory and applications. Prerequisite: Q.B.A. 452.
550. **SEMINAR IN MATHEMATICAL PROGRAMMING (3-6)** Intensive treatment of theory and computational algorithms of mathematical programming; emphasis on operational application to complex management and business problems. Prerequisite: I.E. 510.
561. **STOCHASTIC MODELS FOR MANAGEMENT DECISIONS (3)** Introduction to stochastic processes in business organizations. Application of stochastic models to the conceptualization, analysis, and solution of management problems. Prerequisite: Math. (Stat.) 427.
570. **MANAGEMENT SCIENCE: IMPLEMENTATION AND CONTROL (3)** Development and application of management science models. Model formulation and specification, sensitivity analysis, problems encountered in implementation and control.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

REAL ESTATE (R EST)

400. **URBAN LAND UTILIZATION (3)**
496. **INDEPENDENT STUDIES (1-12)**
497. **SPECIAL TOPICS (1-6)**

CERAMIC SCIENCE (CERSC)

GUY E. RINDONE, *In Charge of Graduate Programs in Ceramic Science*
201 Steidle Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bradt, McKinstry, Newnham, Rindone, Spear, Stubicah, and Tressler.

Graduate Faculty: Associate Member Halloran.

This program is one of the options in which a graduate student in the Department of Materials Science and Engineering can receive an advanced degree. In view of the wide field covered by ceramic science, the graduate courses may be selected with special emphasis in physical ceramics, chemical ceramics, or glass science.

The communication and foreign language requirement may be satisfied by (1) examinations in two languages — French examination administered by the ceramic science faculty and a second language examination by the appropriate language department — or (2) examination in one foreign language and either 6 credits of computer science or 6 credits of statistics, or 3 credits of computer science and 3 credits of statistics.

Special facilities exist for research in the areas of electroceramics, rheology, phase equilibria, solid state synthesis, mechanical properties, ferrite and ferroelectric studies, glass science, and high temperature reaction kinetics. Suitable preparation for graduate study in this program may be found in one of

the material sciences such as ceramics or metallurgy, in engineering fields such as chemical or mechanical engineering, in the basic physical sciences, or in the earth sciences.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

CERAMIC SCIENCE AND ENGINEERING (CERSE)

- 400. NONMETALLIC CRYSTAL CHEMISTRY (2-3) *Newnham*
- 402. PRINCIPLES OF CERAMIC ENGINEERING (3)
- 404. CERAMIC SEMINAR (1) *Hummel*
- 406. RHEOLOGY AND FLUID PROPERTIES OF CERAMIC SYSTEMS (2) *Halloran*
- 407. CERAMIC MATERIALS LABORATORY (2) *Halloran*
- 408. THERMAL PROPERTIES OF CERAMIC MATERIALS (2) *Spear*
- 409. THERMAL PROPERTIES OF CERAMIC MATERIALS LABORATORY (2) *Spear*
- 410. PHASE RELATIONS IN CERAMIC SYSTEMS (3) *Hummel*
- 411. PRINCIPLES OF CERAMIC PROCESSES (2) *Stubican*
- 414. MECHANICAL PROPERTIES OF CERAMICS (3) *Bradt*
- 415. PRINCIPLES OF GLASS TECHNOLOGY (3-4) *Rindone*
- 420. REFRACTORIES (2-3) *Stubican*
- 430. ELECTROCERAMICS (2) *Tressler*
- 431. ELECTROCERAMICS LABORATORY (1) *Tressler*
- 440. CARBON AND GRAPHITE (1) *Thrower*
- 441. CERAMIC NUCLEAR MATERIALS (1) *Spear*
- 496. INDEPENDENT STUDIES (1-12)

CERAMIC SCIENCE (CERSC)

- 500. SEMINAR IN CERAMIC SCIENCE (1-2 per term) Current developments in ceramic science and related fields. Required of all graduate students in ceramic science.
- 501. SURFACE BEHAVIOR OF CERAMIC MATERIALS (2-4) Surface chemistry of ceramics. Rheology of ceramic powders, suspensions, and pastes.
- 502. MECHANICAL PROPERTIES OF CERAMICS I (2) Theoretical considerations of the crystallographic and microstructural aspects of the elastic properties and fracture characteristics of ceramics. Prerequisite: Cersc. 414 or E.Mch. 415. *Bradt*
- 503. USE OF PHASE EQUILIBRIA DATA IN CERAMIC SCIENCE (2-5) Phase equilibria in unary, binary, ternary, and other systems; applications in product development and in understanding behavior of ceramic materials.
- 504. SOLID STATE REACTIONS IN CERAMIC SYSTEMS (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452. *Stubican*
- 505. PHASE TRANSITION IN SOLIDS (2) Phase transitions will be studied in detail with respect to the crystal structure, free energy, and physical properties. *McKinstry*
- 506. MECHANICAL PROPERTIES OF CERAMICS II (2) Theoretical considerations of dislocation processes, diffusion phenomena, and microstructural effects on the deformation and creep of ceramic materials. Prerequisite: Cersc. 502. *Bradt*
- 507. THERMAL PROPERTIES OF CERAMIC MATERIALS (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Tressler*
- 508. DIELECTRIC AND MAGNETIC PROPERTIES OF CERAMIC MATERIALS (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials. *Newnham*
- 509. COMPOSITE MATERIALS (3) Manufacturing processes, atomic and molecular background, and topological relationships of macro- and microstructure to the physical properties of composites. *Tressler*

510. SEMINAR IN GLASS TECHNOLOGY (1-2 per term) Current developments in glass technology and related fields. *Rindone*

511. THE CONSTITUTION OF GLASS (2-3 per term) Historical and current concepts of the atomic structure of glass; relationship of structure to chemical and physical properties. *Rindone*

596. INDIVIDUAL STUDIES (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

NOTE: Courses in the use of X-ray diffraction, electron microscopy, and the electron microprobe in ceramic science studies are listed under Materials Science.

CHEMICAL ENGINEERING (CH E)

LEE C. EAGLETON, *Head of the Department*
160 Merrell R. Fenske Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barton, Braun, Danner, Daubert, Duda, Eagleton, Engel, Kabel, Klaus, Ultman, and Vannice.

Graduate Faculty: Associate Members Peiffer and Tarbell.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, kinetics, catalysis, transport phenomena, unit operations and processes, optimization, polymer physics, bioengineering, process dynamics, mathematical modeling, applied chemistry, surface and colloid chemistry, petroleum technology, rheology, and lubrication. A foreign language is not required for the Ph.D. degree.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Applicants attending foreign universities are required to submit Graduate Record Examination scores. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

CHEMICAL ENGINEERING (CH E)

- 401. CHEMICAL PROCESS ENGINEERING (3)
- 408. CHEMICAL ENGINEERING LABORATORY II (2)
- 413. MASS TRANSFER OPERATIONS (4)
- 414. KINETICS AND INDUSTRIAL CHEMISTRY (4)
- 415. MATHEMATICAL MODELING IN CHEMICAL ENGINEERING (3)
- 416. TECHNIQUES OF PROCESS DESIGN (3)
- 420. CRYOGENIC ENGINEERING (3)
- 422. MODERN PETROLEUM TECHNOLOGY — PROCESSES AND PRODUCTS (3)
- 430. NUCLEAR CHEMICAL ENGINEERING (3)
- 431. ADVANCED INDUSTRIAL CHEMISTRY APPLICATIONS (3)
- 440. CHEMICAL ENGINEERING MATERIALS (3)
- 441. POLYMER PROCESSING (3)
- 445. PROJECTS IN CHEMICAL ENGINEERING (1-6)
- 446. INTRODUCTION TO TRANSPORT PHENOMENA (3)
- 448. ADVANCED MASS TRANSFER OPERATIONS (3)
- 450. PROCESS DYNAMICS (3)
- 453. THERMODYNAMICS FOR CHEMICAL ENGINEERS (3)

- 455. CHEMICAL REACTOR DESIGN (3)
- 460. CHEMICAL ENGINEERING (4)
- 464. DESIGN OF CHEMICAL PLANTS (2)
- 465. DESIGN PROJECTS IN CHEMICAL ENGINEERING (1-6)
- 497. SPECIAL TOPICS (1-6)

- 507. SIMULATION AND MODELING (3) Synthesis of subsystem and system models emphasizing the generality of the principles for application to diverse physical and chemical processes.
- 509. HEAT TRANSFER APPLICATIONS (3) Advanced treatment of steady-state and transient conduction, convection, and radiation, with emphasis on numerical methods and design techniques. Prerequisite: an undergraduate course in heat transfer. *Daubert*
- 516. METHODS OF PROCESS DESIGN (3) Survey of mathematical techniques of chemical process design with emphasis on economic choice and optimal decision making. *Engel*
- 524. CHEMICAL ENGINEERING, APPLICATION OF THERMODYNAMICS (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.
- 535. CHEMICAL REACTION ENGINEERING (3) Optimal design of batch and continuous chemical reactors and reactor batteries; effect of mixing on reactor operation.
- 545. TRANSPORT PHENOMENA I (3) Momentum, heat, and mass transfer, steady and unsteady state, laminar and turbulent flow, coupling, analogies, chemical engineering applications.
- 546. TRANSPORT PHENOMENA II (3) Momentum, heat, and mass transfer, steady and unsteady state, laminar and turbulent flow, coupling, analogies, chemical engineering applications.
- 548. MULTISTAGE MASS TRANSFER OPERATIONS (3) Rigorous solution of complex problems in distillation, extraction, and absorption including computer methods. Prerequisite: an undergraduate course in mass transfer. *Barton*
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

CHEMISTRY (CHEM)

JOSEPH A. DIXON, *Head of the Department*
152 Davey Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Allcock, Anderson, Ascah, Benkovic, Bernheim, Deno, Dixon, Fritz, Geoffroy, Gold, Haas, Hamilton, Heicklen, Hisatsune, Horrocks, Jackman, Jordan, Jurs, Lampe, Lowe, Olofson, Richey, Rosenblatt, Shamma, Skell, Steele, Villafranca, Wartik, Weinreb, and Zook.

Graduate Faculty: Associate Members Matthews and Minard.

The Ph.D. program in chemistry provides students with a broad background in one of the areas of chemistry (analytical, biological, inorganic, organic, or physical) and intensive research experience culminating in the preparation of a formal thesis. The goal of the program is to prepare students for a variety of careers in academia, government, or industry. The general facilities are excellent, and the computer, cryogenic, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussions each Thursday at a departmental colloquium.

The department requires a knowledge of French, German, Japanese, or Russian as a condition for awarding either the M.S. or Ph.D. degree. Candidates who have taken and passed two undergraduate courses in French, German, Japanese, or Russian will be certified as having completed the communication and foreign language requirement. For the M.S. degree the student has the option of writing a thesis or a paper.

For admission, at least integral calculus plus one year's work in general physics, organic chemistry, physical chemistry, and either analytical or inorganic chemistry is normally required. Students who have appropriate course backgrounds and who present a 2.50 average in all undergraduate courses in chemistry, physics, and mathematics will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Prior to scheduling their first term programs, new students will take placement examinations in the areas of analytical, inorganic, organic, and physical chemistry. The information obtained from these tests will assist both the student and the adviser in making up a program best suited to the student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

- 400. CHEMICAL LITERATURE (1)
- 405. NUCLEAR AND RADIOCHEMISTRY (3)
- 408. (Cmp.Sc. 408) COMPUTER APPLICATIONS IN CHEMISTRY (3)
- 410. INORGANIC CHEMISTRY (2)
- 411. ADVANCED INORGANIC CHEMISTRY (2)
- 426. CHEMICAL INSTRUMENTATION (3)
- 427. INSTRUMENTAL ANALYSIS (2)
- 428. INSTRUMENTAL ANALYSIS (2)
- 429. INSTRUMENTAL ANALYSIS (2)
- 431. ORGANIC AND INORGANIC PREPARATIONS (3)
- 435. ADVANCED ORGANIC CHEMISTRY LABORATORY (3)
- 439. STRUCTURAL ANALYSIS OF ORGANIC COMPOUNDS (3)
- 448. SURFACE CHEMISTRY (2)
- *451-452. PHYSICAL CHEMISTRY (3 each)
- 453. ADVANCED PHYSICAL CHEMISTRY (3)
- 454. ADVANCED PHYSICAL CHEMISTRY (3)
- 455. PHYSICAL CHEMISTRY OF HIGH POLYMERS (3)
- *457. EXPERIMENTAL PHYSICAL CHEMISTRY (1-2)
- *458. EXPERIMENTAL PHYSICAL CHEMISTRY (1-2)
- †489. INTRODUCTION TO CHEMICAL RESEARCH (1-10 per term, maximum of 20)
- 500. SEMINAR IN CHEMISTRY (1 per term)
- 516-517. INORGANIC CHEMISTRY (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.
- 518. SPECIAL TOPICS IN INORGANIC CHEMISTRY (3 per term) Modern developments in specialized fields.
- 525. ANALYTICAL PROCESSES (3) Theoretical foundations and contemporary developments.
- 526. MODERN INSTRUMENTAL ANALYSIS (3)
- 527. SPECIAL TOPICS IN ANALYTICAL CHEMISTRY (2-12)
- 531. SPECIAL TOPICS IN ORGANIC CHEMISTRY (3-12) Prerequisite: Chem. 536.
- 534. CHEMICAL APPLICATIONS OF QUANTUM THEORY (3) A development of Molecular Orbital Theory up to the level of present-day usage in organic and inorganic chemistry.
- 535-536. ORGANIC REACTION MECHANISMS I AND II (3 each) Reaction mechanisms and their determination by kinetic and nonkinetic methods. Reactive intermediates. Prerequisite: Chem. 439.

*Graduate credit not allowed for students majoring in chemistry or chemical engineering.

†Graduate credit not allowed for students majoring in chemistry.

537. **SYNTHESIS IN ORGANIC CHEMISTRY (3)** Theory and methods of directed syntheses, including stereospecific and stereoselective schemes; biologically inspired syntheses. Prerequisite: Chem. 536.
544. **CHEMICAL THERMODYNAMICS (3)** Development of thermodynamic theory with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.
545. **STATISTICAL THERMODYNAMICS (3)** The calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisites: Chem. 453 or 544, and Chem. 565.
560. **TOPICS IN PHYSICAL CHEMISTRY (2-6)**
563. **CHEMICAL KINETICS (3)** Theory and measurement of the rates of chemical reactions, molecular dynamics, and mechanisms of chemical reactions. Prerequisites: Chem. 453 or 544, and Chem. 565.
565. **ATOMIC AND MOLECULAR STRUCTURE (3)** Introduction to modern theoretical chemistry, spectroscopy, and structure of atoms and molecules.
566. **QUANTUM CHEMISTRY (3)** Theoretical calculations of electronic properties of atoms and molecules. Prerequisites: A.M. 432 and Chem. 565.
567. **QUANTUM CHEMISTRY (3)** A continuation of Chem. 566, including problems and theories of electron correlation. Prerequisite: Chem. 566.
571. **POLYMER CHEMISTRY (3)** The synthesis, reactions, and structure determination of high polymers.
589. **STUDIES IN CHEMISTRY (1-9)** Theoretical research, experimental research, or a critical survey of the literature in an area of chemistry.
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

CIVIL ENGINEERING (C E)

RAYMOND E. UNTRAUER, *Head of the Department*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Aron, Barnoff, Cady, Crowley, Gotolski, Larson, Long, McDonnell, Miller, Nesbitt, Reed, Regan, Untrauer, Unz, Wang, West, and Willenbrock.

Graduate Faculty: Associate Members Anderson, Chadderton, Chan, Davinroy, Kibler, Marks, McClure, Mozingo, and Thomas.

Students may specialize in structures, hydraulics, hydrology, transportation engineering, traffic engineering, materials, construction, soils, and environmental engineering, or combinations of these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of one foreign language (French, German, or Russian) and proficiency in English. A thesis is required for the M.S. degree. An engineering report is required for the M.Eng. degree.

Candidates normally should be graduates from an accredited program in engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Entering graduate students for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

See also Environmental Engineering.

CIVIL ENGINEERING (C E)

- 400. SEMINAR (1-3)
 - 421. TRANSPORTATION FACILITIES DESIGN (3)
 - 423. TRANSPORTATION SYSTEMS OPERATIONS (3)
 - 424. CIVIL ENGINEERING MATERIALS (3)
 - 427. RAILWAY TRACK STRUCTURE AND TERMINAL SYSTEMS (3)
 - 428. RAILWAY OPERATING SYSTEMS AND ANALYSIS (3)
 - 431. CIVIL ENGINEERING CONSTRUCTION (3)
 - 432. CONSTRUCTION PROJECT CONTROL (3)
 - 446. ADVANCED SOIL MECHANICS (3)
 - 447. STRUCTURAL ANALYSIS BY MATRIX METHODS (3)
 - 448. ADVANCED STRUCTURAL DESIGN (3)
 - 449. DESIGN OF PRESTRESSED AND REINFORCED CONCRETE STRUCTURES (3)
 - 451. ADVANCED HYDROLOGY (3)
 - 452. WATER RESOURCES AND COMPUTATIONS (4)
 - 462. OPEN CHANNEL HYDRAULICS (3)
 - 465. RIVER AND WATERWAYS ENGINEERING (3)
 - 471. ENVIRONMENTAL SANITATION (3)
 - 472. WATER POLLUTION CONTROL PROCESSES (3)
 - 473. WATER QUALITY MANAGEMENT (3)
 - 474. MANAGEMENT OF WATER POLLUTION CONTROL PROCESSES (3)
 - 475. WATER QUALITY CHEMISTRY (1)
 - 476. SOLID WASTE MANAGEMENT (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
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- 511. ENGINEERING SOIL CHARACTERISTICS (3) Physical and chemical factors in soil which influence their engineering properties of strength, deformation, permeability, and soil stabilization. Prerequisite: C.E. 44.
 - 512. APPLIED SOIL MECHANICS (2-5) Soil classification by type of clay minerals and profile development; aerial photographic interpretation of soils and applications to site selection for dams, highways, and airports. Prerequisites: C.E. 44 and 3 credits of geological sciences.
 - 513. SOIL EXPLORATION AND ANALYSIS (3) Laboratory evaluation of parameters used in modern soil mechanics. Involves techniques of soil testing, test limitations, sampling influences, technical reports. Prerequisite: C.E. 44.
 - 518. LAND USE AND TRANSPORTATION MODELS (3) The urban planning process; transportation models; economic, residential, industrial retail and public sector submodels; integrated models; simulation models; evaluative models. Prerequisite: competence in computer applications and transportation principles. Prerequisite: 3 credits of computer science.
 - 520. PAVEMENT DESIGN (3) Fundamental principles; properties of pavement components; design tests; design of flexible pavements; design of rigid pavements; pavement evaluation and strengthening. Prerequisites: C.E. 24, C.E. 44.
 - 521. TECHNIQUES OF TRANSPORTATION ANALYSIS (2-4) Transportation functions, travel patterns, basic analytical methods in the planning content. Prerequisite: 3 credits of computer science.
 - 522. HIGHWAY OPERATIONS (2) Theory and application of traffic controls, including functional operations of traffic signals, systems, and networks; the design of highway lighting. Prerequisite: C.E. 423.
 - 523. URBAN TRANSPORTATION PLANNING, TECHNOLOGY, POLICY, AND ADMINISTRATION (2-4) Characteristics of urban areas, the urban transportation planning process, present and future urban transportation systems, urban transportation policy and administration. Prerequisite: C.E. 21.

524. **ADVANCED PROBLEMS IN CIVIL ENGINEERING MATERIALS (2-6)** Study, in the literature and by laboratory investigation, of selected topics on field-controlled civil engineering materials. Prerequisite: C.E. 424.
525. **AIRPORT PLANNING AND DESIGN (3)** Aircraft characteristics; aeronautical demand; site selection; airport configuration; capacity analysis; design of landing and terminal areas. Prerequisite: C.E. 21.
532. **POWER PLANT CONSTRUCTION (3)** Fossil and nuclear power generation; analysis of power plant design and civil, mechanical, and electrical construction phases; quality assurance role. Prerequisite: C.E. 431.
539. **APPROXIMATE METHODS OF STRUCTURAL ANALYSIS (3)** Newmark's method, finite difference method, and finite element method applied to problems in structural and soil engineering. Prerequisite: C.E. 40.
540. **STRUCTURAL ANALYSIS BY CLASSICAL METHODS (3)** Analysis of continuous trusses and beams, frames, arches, grids, curved beams, suspension systems, and space frames. Prerequisite: C.E. 40.
541. **STRUCTURAL ANALYSIS (3)** Analysis of continuous beams and frames, grids, slabs, shells and three-dimensional structural and soils problems by finite element methods. Prerequisite: C.E. 447.
544. **REINFORCED CONCRETE STRUCTURES (3)** Working stress, ultimate strength, and limit design; test behavior of beams, columns, and slabs. Prerequisite: C.E. 41.
545. **DESIGN OF METAL STRUCTURES (3)** Steel, aluminum members; flexible connections; composite, hybrid, prestressed beams; tension-field beams; buckling; plastic analysis, design; test data; timber design. Prerequisite: C.E. 342.
546. **THIN CONCRETE STRUCTURES (3)** Design of thin concrete structures including slabs, folded plates, and shells. Prerequisite: C.E. 41.
548. **STRUCTURAL DESIGN FOR DYNAMIC LOADS (3)** Dynamic behavior of structural systems of one and more degrees of freedom; earthquake, blast-resistant analysis, and design of structures. Prerequisites: E.Mch. 12 and C.E. 40.
550. **ENGINEERING CONSTRUCTION MANAGEMENT (3)** Management fundamentals for construction contracting; organization, project planning, scheduling and control, bonding and insurance, labor legislation and regulation, cost and control. Prerequisite: C.E. 431.
551. **HYDROLOGIC INVESTIGATIONS (2-8)** Application of hydrologic principles and techniques to a specific project. Prerequisite: C.E. 451 or 452.
552. **HYDROLOGIC PROCESSES AND CYBERNETICS (3)** Application of cybernetic concepts in electronic computer simulation of the hydrologic process-components: infiltration, precipitation, evapotranspiration, and overland flow. Prerequisite: C.E. 51 or 452.
553. **PLANNING MULTIPURPOSE HYDROLOGIC SYSTEMS (3)** Study of multipurpose hydrologic schemes within a social, economical, and political framework. Prerequisite: C.E. 451 or 452; Econ. 14.
554. **URBAN HYDROLOGY (3)** Several hydrograph methods. Design storm and IUH application; airport drainage; flood plains; impact of urbanization upon groundwater and sediment. Prerequisite: C.E. 451 or 452.
560. **DIMENSIONAL ANALYSIS AND THEORY OF MODELS (3)** Principles of dimensional analysis and similitude with engineering applications primarily to problems in hydromechanics. Prerequisite: C.E. 61.
564. **HYDRAULIC ENGINEERING DESIGN (3)** Design and analysis of selected units of a typical hydraulic engineering project. Prerequisite: C.E. 62.
570. **PHYSICAL CHEMICAL TREATMENT PROCESSES I (2)** The theory of physical-chemical processes used in the treatment of potable water and municipal and industrial wastewaters. Prerequisite: C.E. 472.

571. **PHYSICAL CHEMICAL TREATMENT PROCESSES II (3)** The theory of physical-chemical processes used in the treatment of potable water and municipal and industrial wastewaters. Prerequisite: C.E. 472.
572. **BIOLOGICAL TREATMENT PROCESSES (2)** The theory of biological processes used in the treatment of municipal and industrial wastewaters. Prerequisite: C.E. 472.
574. **LABORATORY ANALYSES IN WATER QUALITY CONTROL (3)** Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control. Prerequisite: Chem. 14.
575. **INDUSTRIAL WASTE TREATMENT (2)** Surveys and data analysis; use of unit processes to meet regulatory agency requirements; disposal of gaseous and solid residues. Prerequisite: C.E. 472.
577. **TREATMENT PLANT DESIGN (1-6)** Design of works for the treatment of water and wastewater for municipalities and industries. Prerequisites: C.E. 472 and 3 credits in hydraulics.
579. (Micrb. 529) **AQUATIC MICROBIOLOGY (3)** Ecology and physiology of microorganisms of inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.
580. **STREAM AND ESTUARINE ANALYSIS (3)** Quantitative assessment of advection, reaction, and dispersion processes in polluted waters; reaeration theory; eutrophic systems; analog simulation. Prerequisite: C.E. 472.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

CLASSICS (CLASS)

ARCHIBALD ALLEN, *Head of the Department*
109 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members Carrubba and Donlan.

Graduate Faculty: Associate Member Allen.

The master's degree in classics is intended either as a terminal degree which (combined with the appropriate courses in educational theory and technique) equips students to teach at the elementary or secondary school level, or as preliminary to further graduate study at the doctoral level. The program allows specialization in either Latin or Greek but not to the exclusion of the other language. Although 18 undergraduate credits in some combination of Latin and Greek are the normal minimum requirements for admission, candidates can be admitted with deficiencies in the languages if these are compensated by training in ancient history, civilization, or archaeology. The required 2.50 grade-point average in junior-senior courses, normally considered a minimum for admission, will also be waived in special cases.

Of the 30 graduate credits required for the M.A., 6 may take the form of a supervised thesis. Candidates who choose not to submit a thesis must schedule 6 additional credits of course work. Besides the courses listed below, offered by the Department of Classics, candidates may schedule up to 9 credits in appropriate related subjects — such as ancient history, ancient philosophy, art history, or linguistics — offered by the respective departments. The comprehensive examination comprises a translation paper in either Latin or Greek, an essay exam in three areas of the student's choice in Greek and Latin literature, and a reading examination in a modern language (normally French or German).

GREEK (GREEK)

- 401. INTRODUCTORY READINGS IN GREEK LITERATURE (3)
- 420. THE GREEK HISTORIANS (3)
- 421. GREEK TRAGEDY (3)
- 422. GREEK COMEDY (3)
- 425. HOMER (3)
- 431. PLATO (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

507. PROBLEMS IN GREEK ARCHAEOLOGY (3-9)

509. GREEK SEMINAR (3-9)

517. GREEK RESEARCH (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

LATIN (LATIN)

- 401. INTRODUCTORY READING IN LATIN LITERATURE (3)
- 402. LATIN LITERATURE OF THE REPUBLIC (3-9)
- 403. LATIN LITERATURE OF THE AUGUSTAN AGE (3-9)
- 404. LATIN LITERATURE OF THE EMPIRE (3-9)
- 437. LATIN PROSE COMPOSITION (3-6)
- 461. (Ling. 461) HISTORY OF THE LATIN LANGUAGE (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

500. LATIN LITERATURE (3-9) Readings in the major forms of Latin literature; content varies; course may be repeated.

510. LATIN SEMINAR (3-6)

518. LATIN RESEARCH (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

***CLASSICS (CLASS)**

- 405. STUDIES IN GREEK MYTHOLOGY (3)
- 408. GREEK RELIGION AND MODERN MAN (3)
- 410. CLASSICAL EPIC (3)
- 411. CLASSICAL DRAMA (3)
- 496. INDEPENDENT STUDIES (1-12)

500. INTRODUCTION TO CLASSICAL SCHOLARSHIP (1-6) Lectures on the methods and materials of classical scholarship. To be scheduled by graduate students in their first term and as necessary thereafter.

504. TOPOGRAPHY OF ANCIENT ROME (3) Lectures and readings on physical development of the ancient city of Rome from earliest habitation to time of later empire.

597. SPECIAL TOPICS (1-6)

*The readings are in English; knowledge of Greek and Latin is not required.

COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (CSP D)

GORDON D. BROWN, *Chairman of Graduate Programs in Community Systems Planning and Development*

S-210 Henderson Human Development Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Brown, Bullington, Freeman, Gamm, Gunter, Hunt, Katkin, Mann, Miller, Raffel, Ritti, Vallance, Woolley, and Young.

Graduate Faculty: Associate Members Eisele, Ellis, Fisher, Fox, Guttenplan, Hill, Hussey, Hyman, Kramer, Mayers, Meyer, and Price.

This interdisciplinary program provides instruction in content and research methods relating to the coordinated planning, development, administration, and evaluation of a range of community services in the three professional areas of health and medical care services, justice services, and community social services.

The aim of the program is to build the knowledge base and skills necessary to develop policies and programs for the effective delivery of human services to individuals and communities. Graduates of the program will be able to identify major community subsystems and recognize community problems and dysfunctions, expressing their relative seriousness in terms of economic and social costs. Graduates will have skill in working with members of the community and with community institutions to develop ways of coping with such problems and to facilitate the creation of interventions which will improve the quality of life. In addition, they will have the skills necessary to evaluate the effectiveness of these interventions.

The Ph.D. program prepares professionals, researchers, and teachers with the necessary conceptual and technical skills to identify and analyze elements of human service systems and to develop, implement, and evaluate programs designed to improve the quality of life. Ph.D. students will develop considerable understanding of all human service systems and might elect to develop a master's level competency in one of the professional areas represented in the program. The communication requirements for the Ph.D. can be satisfied by demonstration of proficiency through examination in a foreign language or a set of computer languages. The M.S. program will prepare individuals for professional-level work in health planning and administration, administration of justice, or community social services. Career opportunities include administration and planning positions in hospitals and health facilities, community mental health, social services, criminal justice planning agencies, courts, and corrections programs. A thesis is required for the M.S. degree.

Preference will be shown to applicants who have a broad background in the social sciences. Proficiency in quantitative skills such as mathematics and statistics is also desirable. In general, a 3.00 junior-senior average is expected of applicants, but consideration will be given to prior graduate education and professional work experience.

Special research and training facilities include the Institute for the Study of Human Development, the University Computation Center, and a simulation laboratory.

COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (CSP D)

500. INTRODUCTION TO COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (3) Introduction to applied general systems theory; applications to analysis of community systems and to the planning of community human services.

501. HEALTH CARE ORGANIZATION (3) Examination of health systems, organization, financing, and evaluation; trends, problems, and issues.

510. HEALTH PROBLEM ANALYSIS (3) Logic of empirical inquiry in study of community problems in health. Integration of theory and practice, technical data and values.

521. **VALUES AND GOALS IN THE ADMINISTRATION OF JUSTICE (3)** The justice system from perspective of clientele, service personnel, and the system. Meeting service requirements in community and institutional settings.
523. **ISSUES AND TRENDS IN THE DEVELOPMENT OF SOCIAL WELFARE SERVICES (3-6)** Examination of selected issues affecting the development of social welfare functions and services.
531. **COMMUNITY DYNAMICS AND SOCIAL SERVICES (3)** Classic and contemporary community organization theory, social planning and change, decision making, human services planning and action, community action, community research.
532. **INTERFACE PROBLEMS OF COMMUNITY SERVICE SYSTEMS (3)** Exploration of consequences of policy decisions and action in one or more social service systems on other community systems.
533. **BEHAVIORAL ASSUMPTIONS AND STRATEGIES IN THE PROCESS OF PLANNED CHANGE (3)** A general systems approach to the assumptions beneath various social problem strategies and consequences associated with each intervention-set.
534. **FORECASTING METHODS AND SOCIAL POLICY PLANNING (3)** Analysis of predictive methods for forecasting social change. Prerequisites: Econ. 405, Stat. 200.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

COMPARATIVE LITERATURE (C LIT)

CAROLINE D. ECKHARDT, *In Charge of Graduate Programs in Comparative Literature*
N424 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Begnal, Carrubba, Ebbinghaus, Frank, Kopp, Lewis, Lima, Walden, Ward, Weintraub, and West.

Graduate Faculty: Associate Members Balaban, Eckhardt, Fitz, Grecco, Hale, Knight, and Peavler.

Programs of study combine a core of comparative literature courses with courses in several national literatures (two for the master's degree and three for the doctoral degree) according to the student's interests. These programs can be designed to concentrate on such topics as genres, themes, periods, movements, folklore, criticism, the influence of literary works, and the relationships among national literatures and between literature and other disciplines.

Requirements for the M.A. degree include (1) 9 credits in comparative literature (3 credits of which must be C.Lit. 501), 9 credits in one national literature, and 6 credits in a second national literature; (2) proficiency in the languages of the two literatures (one of which may be English); (3) a written comprehensive examination based on a reading list; and (4) 6 thesis credits.

Students with a 3.00 junior-senior average and appropriate course backgrounds (including preparation in a foreign language) will be considered for admission to the master's program. Exceptions may be made for students with special backgrounds and abilities.

Requirements for the Ph.D. degree include (1) 9 credits in comparative literature (C.Lit. 501, 502, and 503, unless these have been part of the M.A. degree program) and at least 21 credits in either a concentration in national literatures or a concentration in a period, genre, theme, or area study; (2) an oral candidacy examination; (3) proficiency in the languages of three literatures studied (one of which may be English); (4) a written comprehensive examination based on a reading list; and (5) a thesis.

Students holding or completing a master's degree in an appropriate field, and prepared to work in three national literatures, will be considered for admission to the doctoral program.

COMPARATIVE LITERATURE (C LIT)

- 400. SENIOR SEMINAR IN COMPARATIVE LITERATURE (3)
- 401. WESTERN LITERATURE I (3) *Eckhardt and Knight*
- 402. WESTERN LITERATURE II (3) *Knight and Condee*
- 403. WESTERN LITERATURE III (3) *Begnal and Peavler*
- 407. LITERATURE RELATING TO THE SOUTH SEAS (3) *Martin*
- 408. HEROIC EPIC AND SONG (3) *Bayard, Thigpen, and Bowden*
- 422. AFRICAN DRAMA (3) *Hale*
- 423. AFRICAN NOVEL (3) *Hale*
- 443. (Ger. 443) LITERARY RELATIONS OF GERMANY WITH ENGLAND AND AMERICA (3-9) *Kopp and Lewis*
- 470. OLD MASTERS OF THE MODERN NOVEL (3) *Begnal and Ward*
- 480. INTRODUCTION TO FOLKLORE (3) *Thigpen*
- 486. TRAGEDY (3) *Grecco and Lima*
- 487. COMEDY (3) *Knight and Lima*
- 488. (Engl. 488) MODERN CONTINENTAL DRAMA (3) *Grecco*
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 500. SEMINAR IN COMPARATIVE LITERATURE (3-6)
- 501. COMPARATIVE METHOD IN LITERARY STUDIES (3) Bibliography, research methods, and studies in comparative literature. *Eckhardt and Ward*
- 502. COMPARATIVE CRITICISM I: CLASSICAL TO NEOCLASSICAL (3) Issues in literary criticism from Plato and Aristotle to the mid-eighteenth century. *Ward*
- 503. COMPARATIVE CRITICISM II: ROMANTIC TO CONTEMPORARY (3) Principles and theories of literary criticism from eighteenth- and nineteenth-century beginnings to twentieth-century expansion and application. *Ward*
- 508. NORSE AND GAELIC SAGAS (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to background, development, themes, and characteristics. *Bayard and Ebbinghaus*
- 570. FORCES IN CONTEMPORARY EUROPEAN LITERATURE (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *West*
- 588. TWENTIETH-CENTURY DRAMA (3) The comparative analysis of major plays of the twentieth century. *Grecco and Lima*
- 593. (Engl. 593) ANGLO-AMERICAN FOLK SONG (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present. *Bayard*
- 596. INDIVIDUAL STUDIES (1-6)

COMPUTER SCIENCE (CMPSC)

JONATHAN GOLDSTINE, *Acting Head of the Department*
303 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Culik, deMaine, C. Fischer, P. Fischer, Goldstine, D. Johnson, and Laird.

Graduate Faculty: Associate Members Downey, Frederickson, Gonzalez, Gudes, Heller, Irwin, Ja'Ja', G. Johnson, Seiferas, Simon, Spirn, Tsur, and Wotschke.

The department offers courses and is prepared to direct research in a variety of subfields of computer science, including data bases and information retrieval, foundations of computer science, analysis of algorithms, computational complexity, formal language theory, operating systems, and numerical analysis. The Computation Center has modern facilities available for research and instruction. The department operates a Computer Systems Laboratory for instruction.

Admission to the M.S. program without deficiency requires that an applicant should have completed at least 9 credits of computer science at the advanced undergraduate level from the areas of data structures, programming languages and compiler design, computer organization and operating systems, numerical analysis, and language and automata theory. In addition, the student is expected to have mathematics training which includes calculus, linear algebra, and some discrete mathematics.

The M.S. candidate must satisfactorily complete the requirements of the Graduate School. In addition, at least 12 of the required 500-level credits shall be regular courses in the Department of Computer Science meeting certain distribution requirements described in the departmental brochure, *Graduate Study in Computer Science at Penn State*. The nonthesis option is available for the M.S. degree. The candidate may also be required to demonstrate proficiency in the design and implementation of computer programs or computer-related systems, or both.

The Ph.D. degree is primarily a research degree and is conferred on the basis of original work and high academic achievement in computer science. In order to be accepted as a candidate the student must pass a written candidacy examination. The communication and foreign language requirement for the Ph.D. degree may be satisfied by a proficiency in one foreign language (French, German, or Russian). These and additional requirements are detailed in the departmental brochure cited above.

Students with at least a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. The department requires scores on the Graduate Record Examination Aptitude Test from all applicants.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D and M.S. degrees (see p. 238).

COMPUTER SCIENCE (CMPSC)

- 400. PROGRAMMING LANGUAGE CONCEPTS (3)
- 402. INTRODUCTION TO COMPUTER PROGRAMMING (3)
- 404. INFORMATION STRUCTURES (3)
- 408. (Chem. 408) COMPUTER APPLICATIONS IN CHEMISTRY (3)
- 410. COMPUTER ORGANIZATION AND OPERATION (3)
- 411. OPERATING SYSTEMS (3)
- 420. COMPILER CONSTRUCTION (3)
- 430. COMBINATORICS AND GRAPH THEORY (3)
- 440. INTRODUCTION TO DATABASE MANAGEMENT SYSTEMS (3)
- 442. ADVANCED PROGRAMMING AND JOB CONTROL LANGUAGE (3)
- 444. SYSTEMS AND PROGRAM DESIGN IN EDP (3)
- 453. (Math. 453) NUMERICAL COMPUTATIONS (3)
- 454. (Math. 454) MATRIX COMPUTATIONS (3)
- 468. MATHEMATICAL MACHINE THEORY (3)
- 491. COMPUTER PROJECTS (1-12)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

500. THEORY OF AUTOMATA (3) The structure of finite automata and sequential machines including characterization theorems, minimization problems, state identification experiments, and decomposition theory. Prerequisite: Cmp.Sc. 468.

510. PARSING, TRANSLATION, AND COMPILING (3) Principles of compiler design: lexical analysis, parsing methods, semantic analysis, code generation, and optimization. Prerequisites: Cmp.Sc. 420, 468.

511. OPERATING SYSTEMS (3) Concurrent processes, synchronization and deadlock, scheduling models, queueing models, memory management, and security. Prerequisites: Cmp.Sc. 411; Stat. (Math.) 418.
530. MACHINE INTELLIGENCE AND HEURISTIC PROGRAMMING (3) Methods for making machines behave intelligently; problem solving, theorem proving, game playing, question answering, learning, induction; specialized languages and data structures. Prerequisite: Cmp.Sc. 420.
534. ALGORITHM DESIGN AND ANALYSIS (3) Data structures and programming techniques useful in the design of efficient algorithms; algorithm analysis; computational complexity. Prerequisite: Cmp.Sc. 404.
535. THEORY OF GRAPHS AND NETWORKS (3) Theory and applications of graphs including structure of graphs, network analysis, and algorithms for computer solution of graph-theoretic problems. Prerequisite: Cmp.Sc. 430.
537. (B.A. 537) MANAGEMENT INFORMATION SYSTEMS DESIGN (3) Cost, value, and technical considerations in analysis and design of information systems whose purposes are to aid decision making in organizations.
540. INFORMATION PROCESSING SYSTEMS (3) Data structures and data processing; information retrieval systems. Prerequisite: Cmp.Sc. 411.
545. INFORMATION RETRIEVAL (3) Input-output, design, implementation, evaluation, global memories, and comparison of information retrieval systems. Prerequisite: Cmp.Sc. 540.
551. (Math. 551) NUMERICAL ALGEBRA (3) Zeros of polynomials; iterative solution of linear and nonlinear systems; sparse matrix techniques; eigenvalues and eigenvectors. Prerequisite: Cmp.Sc. 454 or Math. 441.
552. (Math. 552) INTRODUCTION TO APPROXIMATION THEORY (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 3 credits in computer science.
553. (Math. 553) NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS (3) Methods for initial value and boundary value problems. Stability and convergence analysis, automatic error control, and stiff systems. Prerequisites: Cmp.Sc. 453, Math. 431.
559. COMPUTABILITY AND RECURSIVE FUNCTIONS (3) Mathematical treatment of computability, recursive functions, Turing machines, unsolvable problems, recursive and recursively enumerable sets. Prerequisite: Cmp.Sc. 468.
564. (Math. 564) NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS (3) Methods of parabolic, hyperbolic, and elliptic partial differential equations; finite difference and variational methods; splines, finite elements. Prerequisites: Cmp.Sc. 453, 454; A.M. (Math) 451 or 432.
- 568-569. THEORY OF FORMAL LANGUAGES AND AUTOMATA (3 each) Generation and recognition of formal languages, grammars, Chomsky's hierarchy of languages, closure properties, characterization by automata, algebraic properties, complexity classification. Prerequisite: Cmp.Sc. 468.
579. (Math. 579) SPECIAL TOPICS IN NUMERICAL ANALYSIS (2-12)
590. COLLOQUIUM (1-3)
591. SPECIAL TOPICS IN COMPUTER SCIENCE (2-6)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

COUNSELOR EDUCATION (CN ED)

EDWIN L. HERR, *Head of the Division of Counseling and Educational Psychology*
201 Carpenter Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Baker, Britton, Herr, Horan, Hudson, Keat, Kelz, and Swisher.

Graduate Faculty: Associate Members Bandt, Craighead, and Moore.

Professional preparation is offered at the master's level for school counselors (elementary and secondary), college counselors or persons entering college student personnel services, and rehabilitation counselors. Doctoral programs prepare candidates for positions of responsibility and leadership in these same areas, as well as in the education of counselors and in counseling research and practice. Doctoral candidates must have a minimum of one year of work experience in their field.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a comprehensive knowledge of one foreign language and courses from other designated areas, or by options from designated areas selected to include competence in statistics, research design, computer application, or electronic data processing.

All candidates for graduate degrees in counselor education must present for admission at least 27 undergraduate credits of 3.00 or better, distributed among at least three of the following areas: economics, education, psychology, sociology, and physiology or anatomy.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Doctoral candidates should present at least a 3.33 average in all graduate study completed.

All candidates are expected to exhibit, in addition to academic competence, effectiveness in interpersonal relations and in both written and oral communication. They must also evidence support of professional counseling activities and organizations.

A candidate for either a Ph.D. or a D.Ed. degree must earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree, preferably at the thesis planning and writing stage.

COUNSELOR EDUCATION (CN ED)

- 403. FOUNDATIONS OF GUIDANCE AND COUNSELING PROCESSES (3)
- 404. GROUP PROCEDURES IN GUIDANCE AND COUNSELING (3)
- 408. INTRODUCTION TO VOCATIONAL REHABILITATION (3)
- 409. MEDICAL INFORMATION FOR COUNSELORS (3)
- 410. REHABILITATION OF THE MENTALLY ILL (3)
- 412. REHABILITATION FACILITIES AND SERVICES OF PENNSYLVANIA (3)
- 413. REHABILITATION CASE RECORDING AND MANAGEMENT (3)
- 415. COUNSELING ADULTS (3)
- 417. (Vo.Ed. 417v) CAREER EDUCATION: ORIGINS, THEORY, IMPLEMENTATION (3)
- 425. THE USE OF TESTS IN COUNSELING (3)
- 470. WORKSHOP IN STUDIES IN COUNSELOR EDUCATION (1-6)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. COUNSELING: THEORY AND METHOD (3) Theory and methods of counseling individuals whose problems of choice, decision, and adjustment fall within the normal range. Prerequisite: Cn.Ed. 403 or 408 or 551.
- 502. ADVANCED COUNSELING THEORY AND METHOD (3) Assessment, intervention, and evaluation procedures for counseling problems frequently encountered in school, college, and rehabilitation settings. Prerequisite: Cn.Ed. 501.

503. GUIDANCE SERVICES IN ELEMENTARY EDUCATION (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals. Prerequisite: Cn.Ed. 403.
504. GUIDANCE SERVICES IN SECONDARY EDUCATION (3) Nature and scope of guidance in secondary schools — services, models, and strategies; the counselor as an agent of change. Prerequisite: Cn.Ed. 403.
505. FOUNDATIONS OF COUNSELING INFORMATION (3) Accelerating change in economic, psychological, social, educational influences upon counselees. Utilization of information systems in effecting counselee change. Prerequisite: Cn.Ed. 403 or 408 or 504 or 551.
506. INDIVIDUAL ANALYSIS AND COUNSELING PROCEDURES (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing. Prerequisites: Ed.Psy. 451; Cn.Ed. 408 or 503 or 504.
507. COUNSELING PRACTICUM (1-6) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Cn.Ed. 506.
508. ORGANIZATION AND ADMINISTRATION OF GUIDANCE PROGRAMS (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: Cn.Ed. 506.
509. CONTRIBUTIONS OF PROFESSIONAL PERSONNEL TO VOCATIONAL REHABILITATION (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisites: Cn.Ed. 403, 408.
511. SUPERVISED PRACTICUM IN REHABILITATION COUNSELING (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Cn.Ed. 403, 408.
512. PROFESSIONAL EXPERIENCE IN REHABILITATION COUNSELING (1-10) Supervised internship with responsibility for a regular case load. Prerequisites: Cn.Ed. 403, 409, 501, 507.
513. SUPERVISION OF COUNSELORS (3-9) Practical experience in supervising and evaluating work of counselors. Prerequisite: Cn.Ed. 507.
516. EVALUATION OF PROJECTS IN SCHOOL GUIDANCE (2-6) Implementation and evaluation of program development projects in cooperation with state or local guidance programs. Prerequisite: 15 credits in counselor education.
517. ELEMENTARY SCHOOL COUNSELING INTERNSHIP AND SEMINAR (1 per term, maximum of 3) Off-campus, supervised internships in elementary school settings with supplementary related topics, discussion, and skills training in on-campus seminars. Prerequisite: Cn.Ed. 503.
518. SECONDARY SCHOOL COUNSELING INTERNSHIP AND SEMINAR (1 per term, maximum of 3) Off-campus, supervised internships in secondary school settings with supplementary related topics, discussion, and skills training seminars. Prerequisite: Cn.Ed. 504.
551. STUDENT PERSONNEL SERVICES (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; cocurricular activities; student welfare.
553. STUDENT PERSONNEL SERVICES PROGRAMMING (2-3) Formulation of policies as guides to the student personnel service programs; integration of program elements; research; current problems and trends. Prerequisites: Cn.Ed. 551, Hi.Ed. 545.
555. CAREER COUNSELING (3) The examination of historical, legislative, and current models of career counseling and the development of pertinent individual and group techniques. Prerequisite: Cn.Ed. 505.
591. SEMINAR IN COUNSELING: HISTORY AND TRENDS (1) Discussion of the history of guidance and counseling, emphasizing how the past has shaped the present and portends the future. Prerequisite: 9 credits in counselor education.
592. SEMINAR IN COUNSELING: LEGAL AND ETHICAL CONCERNS (1-2) Study and discussion of legal, ethical, and professional concerns of counselors; privileged communication, data banks, and privacy invasion. Prerequisite: 9 credits in counselor education.

- 593. SEMINAR IN COUNSELING: PHILOSOPHY (1) Study and discussion of such philosophical foundations of counseling as phenomenology, idealism, realism, existentialism, and daseinanalytic, theological, and other contemporary thoughts. Prerequisite: 9 credits in counselor education.
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

CURRICULUM AND INSTRUCTION (C I)

CAROL A. CARTWRIGHT, *In Charge of Graduate Programs in Curriculum and Instruction*
155 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Alessandro, Askov, Bell, Bixby, Bliesmer, Brewer, Cartwright, M. Dupuis, V. Dupuis, Dwyer, Fagan, Fowler, Golub, Heilman, Heimer, Hermanowicz, Koble, Madsen, Searles, Shemick, Short, Shrigley, Szabo, Trueblood, Welliver, Withall, F. Wood, Yawkey, and Zaffroni.

Graduate Faculty: Associate Members Alfke, Hogg, Johnson, Marbach, Nelson, Nicely, Sharp, White, and N. Wood.

This program provides advanced professional preparation in the special areas of supervision and curriculum development, bilingual education, early childhood education, elementary education, instructional media, language arts and reading, science education, social studies education, and mathematics education. Candidates for the Ph.D. and D.Ed. degrees must meet all requirements, described in the earlier sections of this catalog. To meet residency requirements, the Ph.D. candidate must spend at least three consecutive terms enrolled as a full-time student at the University Park Campus. The D.Ed. candidate must spend at least three of any five consecutive terms enrolled as a full-time student at the University Park Campus.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages.

Candidates for the D.Ed. degree with a minor in curriculum and instruction must take a minimum of 15 course credits approved in advance by the person in charge of graduate programs in curriculum and instruction. Candidates for the M.Ed. degree with a minor in curriculum and instruction must take a minimum of 6 course credits approved in advance.

For admission to the professional degrees of M.Ed. and D.Ed., teaching or equivalent experience and at least 18 credits in education are recommended. Students with a 2.75 junior-senior average and with appropriate course and professional backgrounds will be considered for admission, subject to the limitation of program facilities.

CURRICULUM AND INSTRUCTION (C I)

- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

CURRICULUM AND SUPERVISION (C & S)

- 400. INTRODUCTION TO RESEARCH LITERATURE (3)
- 401. MEASUREMENT AND EVALUATION OF INSTRUCTION, K-12 (3)
- 402. PROFESSIONAL TERM IN ELEMENTARY EDUCATION (12)
- 403. PRACTICUM IN STUDENT TEACHING (10)
- 404. PROFESSIONAL ORIENTATION OF THE ELEMENTARY TEACHER (3)
- 405. STRATEGIES IN CLASSROOM MANAGEMENT (3)
- 451. INSTRUCTION IN EARLY CHILDHOOD EDUCATION DERIVED FROM DEVELOPMENTAL THEORIES (3)
- 452. ANALYSIS OF MODEL EARLY CHILDHOOD EDUCATION PROGRAMS (3)
- 454. (I.F.S. 454) DEVELOPMENT AND ADMINISTRATION OF CHILD SERVICE PROGRAMS (3)

- 470. WORKSHOP IN SELECTED STUDIES IN CURRICULUM (1-6)
 - 471. WORKSHOP IN SELECTED STUDIES IN SUPERVISION (1-6)
 - 473. SECONDARY EDUCATION IN AMERICA (3)
 - 490. (Human. 490) HUMANITIES FOR TEACHERS (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
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- 570. PROBLEMS SEMINAR FOR EXPERIENCED EDUCATORS (3) Historical, psychological, social, and economic factors influencing educational programs. Prerequisite: 12 credits in education and psychology.
 - 571. SEMINAR IN CONTEMPORARY ISSUES IN ELEMENTARY EDUCATION (1-3) Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisites: 6 credits in elementary education and teaching experience.
 - 572. ISSUES AND TRENDS IN EARLY CHILDHOOD EDUCATION (3) Research, experimental programs and emerging trends in early childhood education; relationships between educational experiences and later intellectual and emotional development. Prerequisites: C.&S. 472, Ed.Psy. 400.
 - 573. ORGANIZATION OF THE ELEMENTARY SCHOOL CURRICULUM (3) Principles underlying curriculum construction. Primarily for elementary education majors. Prerequisite: C.&S. 402 or teaching experience.
 - 575. ORGANIZATION OF THE SECONDARY SCHOOL CURRICULUM (3) Functions of laymen, pupils, teachers, supervisors, and administrators in secondary school curriculum construction. Prerequisites: 12 credits in education and psychology, and teaching experience.
 - 576. CURRICULUM THEORY K-12 (3) The analysis and use of the foundations which underlie models of curriculum design. Prerequisite: C.&S. 573 or 575.
 - 577. SEMINAR IN CURRICULUM RESEARCH (3) Seminar designed to meet the need for special study of particular research projects in elementary and secondary education. Prerequisite: 12 credits of graduate work in education.
 - 578. STANDARD WORKS IN CURRICULUM AND INSTRUCTION (3) Study of significant empirical, historical, evaluative, philosophical, and critical works having an impact on curriculum and instruction practice. Prerequisite: C.&S. 576.
 - 580. SUPERVISION OF STUDENT TEACHERS (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education including at least 5 in methods.
 - 581. PRINCIPLES OF INSTRUCTIONAL SUPERVISION (3) Social and institutional settings for instructional supervision; functions, activities, and practices of supervision; supervisory case studies.
 - 582. SYSTEMATIC OBSERVATION OF INSTRUCTION (3) Construction and use of valid and reliable systematic observation systems used as a basis for classroom observation of instruction. Prerequisite: student teaching or teaching experience.
 - 583. INTERNSHIP IN CURRICULUM AND SUPERVISION (3-6) Internship in schools or educational facilities where student is not employed, under supervision of graduate faculty in student's major area.
 - 588. PROBLEMS, PROJECTS, AND AREA STUDIES IN CURRICULUM AND INSTRUCTION (1-6) Independent work in the study of topics in curriculum and instruction; development of new curricula, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of program chairman.

INDUSTRIAL ARTS EDUCATION (IA ED)

- 460. PLANNING AND MANAGEMENT OF INSTRUCTIONAL RESOURCES (3)
- 461. CONSTRUCTION ACTIVITIES IN THE ELEMENTARY SCHOOL (3)
- 462. PROBLEMS IN INDUSTRIAL ARTS (2)

- 464. CURRICULUM AND INSTRUCTION: INDUSTRIAL STUDIES (3)
- 465. PREPROFESSIONAL EXPERIENCE IN INDUSTRIAL STUDIES (1-3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

561. HISTORY AND PHILOSOPHY OF INDUSTRIAL ARTS (2-3) Historical developments and concurrent educational philosophies of industrial arts in American education.

562. CURRICULUM DEVELOPMENT IN INDUSTRIAL ARTS EDUCATION (2-3) Analysis of curriculum innovations in industrial arts and cognate fields; strategies for implementing curricular change; construction and assessment of curriculum materials. Prerequisite or concurrent: I.A.Ed. 561. Prerequisite: teaching experience.

563. SUPERVISION AND ADMINISTRATION OF INDUSTRIAL ARTS EDUCATION (2-3) How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisite or concurrent: I.A.Ed. 562. Prerequisite: teaching experience.

564. EVALUATION IN INDUSTRIAL ARTS (2-3) Construction of informal manipulative and written tests; use of standardized mechanical aptitude tests; construction and use of performance rating scales. Prerequisite: C.&S. 400 or 401.

568. RESEARCH IN INDUSTRIAL ARTS (2-3) Research techniques in industrial arts education. Prerequisite or concurrent: C.&S. 400.

569. SEMINAR IN INDUSTRIAL ARTS (1-9) Directed intensive study, investigation or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INSTRUCTIONAL MEDIA (INSTM)

- 411. ORIENTATION TO INSTRUCTIONAL MEDIA (2)
- 412. PRODUCTION AND UTILIZATION OF GRAPHIC STIMULUS MATERIALS (3)
- 413. PRODUCTION OF EDUCATIONAL MOTION PICTURES (3)
- 414. TELEVISION IN EDUCATION (3)
- 415. SYSTEMATIC INSTRUCTIONAL DEVELOPMENT (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

511. ORGANIZATION AND ADMINISTRATION OF MEDIA IN SCHOOLS (3) Problems of providing instructional media in schools; the role of the media consultant in curriculum construction. Prerequisite: Inst.M. 411.

532. SURVEY OF MEDIA RESEARCH (3) Systematic study of media research in educational applications of television, still and motion pictures, graphic and simulated environments. Prerequisite: Ed.Psy. 400.

MATHEMATICS EDUCATION (MTHED)

- 420. TEACHING MATHEMATICS IN THE ELEMENTARY SCHOOLS (3)
- 421. TEACHING MATHEMATICS IN THE SECONDARY SCHOOLS (4)
- 422. INDIVIDUALIZING INSTRUCTION IN SCHOOL MATHEMATICS (3)
- 424. CONTEMPORARY ELEMENTARY SCHOOL MATHEMATICS PROGRAMS (3)
- 425. CONTEMPORARY SECONDARY SCHOOL MATHEMATICS PROGRAMS (3)
- 427. COMPUTERS AND THE TEACHING OF MATHEMATICS (3)
- 470. SELECTED STUDIES IN MATHEMATICS EDUCATION (1-6)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

520. ANALYSIS OF RESEARCH IN MATHEMATICS EDUCATION (3) Survey of the status of knowledge about mathematics learning and instruction, K-12; analysis of research procedures; instruments for evaluating research. Prerequisites: Mth.Ed. 420 or 421, 3 credits in statistics, and teaching experience.

521. STRATEGIES FOR RESEARCH IN MATHEMATICS EDUCATION (3) In-depth analysis of strategies for research in mathematics education; conditions for applying the scientific model; implications for research and development. Prerequisite: Mth.Ed. 520.

525. RESEARCH PARTICIPATION IN SCHOOL MATHEMATICS CURRICULUM CONSTRUCTION (3) Development of theoretical bases for the construction of instructional materials in mathematics, research participation in preparing and testing curriculum materials. Prerequisite: Mth.Ed. 521.

READING, COMMUNICATION, AND LANGUAGE EDUCATION (RCLED)

400. TEACHING READING IN THE ELEMENTARY SCHOOL (3)

401. METHODS OF TEACHING LANGUAGE ARTS IN ELEMENTARY SCHOOL (3)

402. TEACHING CHILDREN'S LITERATURE (3)

403. TEACHING ENGLISH IN THE SECONDARY SCHOOLS (4)

405. READING PROBLEMS IN THE SECONDARY SCHOOLS (2)

420. TEACHING READING AND LITERATURE TO ADOLESCENTS (3)

424. SEMINAR IN FOREIGN LANGUAGE AND BILINGUAL EDUCATION (3)

440. FUNDAMENTALS OF READING INSTRUCTION (3)

442. THE ELEMENTARY SCHOOL LANGUAGE ARTS PROGRAM (3)

443. TEACHING LANGUAGE AND COMPOSITION (3)

445. TEACHING ENGLISH IN BILINGUAL/DIALECTAL EDUCATION (3)

446. REMEDIAL READING IN THE CLASSROOM (3)

450. CONTENT AREA READING (3)

467. INTERGROUP STORYTELLING (3)

470. SELECTED STUDIES IN READING, COMMUNICATION, AND LANGUAGE EDUCATION (1-6)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

526. (Ed.Psy. 526) THE PSYCHOLOGY OF READING (3) Psychological principles underlying the process of reading and comprehending with application to instruction. Prerequisite: Ed.Psy. 421.

540. TEACHING READING: LINGUISTICS PERSPECTIVE (3) Examination of reading as language and thought processes; contributions of linguistics, orthography, semantics, and syntax to instructional strategies. Prerequisites: undergraduate reading course and teaching experience.

541. CHILDREN'S LITERATURE RELATED TO ETHNIC AND SOCIAL ISSUES (3) Children's literature, K-12; study of literary symbolism, ethnic literature, and controversial issues; bibliotherapy, censorship, sex education through the trade book. Prerequisite: RCLEd.402.

542. ISSUES IN READING, COMMUNICATION, AND LANGUAGE EDUCATION (3 per term, maximum of 6) Issues in curriculum development and research in reading, communication, and language education, K-12, instructional materials analysis, and development. Prerequisites: RCLEd.403 or 405; and teaching experience.

543. RESEARCH IN THE TEACHING OF READING, COMMUNICATION, AND LANGUAGE EDUCATION (3 per term, maximum of 6) Cooperative study of problems and research findings in the teaching of reading, communication, and language education in American schools. Prerequisite: RCLEd.403 or 405; and teaching experience.

545. DIAGNOSTIC TESTING IN READING (3) Practicum in diagnosing reading difficulties, elementary and secondary levels; achievement, diagnostic, and capacity tests; informal inventories; genesis of reading problems. Prerequisite: RCLEd.440.

550. THEORY AND PRACTICUM IN REMEDIAL READING FOR ELEMENTARY STUDENTS (3) Supervised practicum with young children where remediation designs are analyzed, applied, and evaluated. Prerequisites: RCLEd.440 or equivalent teaching experience, and RCLEd.545.

551. THEORY AND PRACTICUM IN REMEDIAL READING FOR SECONDARY/ADULT LEARNERS (3) Supervised practicum work with secondary/adult/remedial students based upon theories and research concerning the reading problems of young adults. Prerequisite: RCLEd.550.

557. PRACTICUM: REMEDIAL PROCEDURES AND DIAGNOSIS (3-6) Advanced practicum; diagnostic testing and remedial instruction of more severe types of reading disability; newer and special materials and procedures. Prerequisite: RCLEd.545.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

SCIENCE EDUCATION (SCIED)

454. SCIENCE IN EARLY CHILDHOOD EDUCATION (3)

455. FIELD NATURAL HISTORY FOR TEACHERS (3)

456. TEACHING OF CONSERVATION OF NATURAL RESOURCES IN THE SCHOOLS (3)

457. TEACHING OF ENVIRONMENTAL EDUCATION IN THE SCHOOLS (3)

458. TEACHING SCIENCE IN THE ELEMENTARY SCHOOL (3)

459. TEACHING SCIENCE IN THE SECONDARY SCHOOL (4)

470. SELECTED STUDIES IN SCIENCE EDUCATION (1-6)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

556. THE SUPERVISION OF SCIENCE CURRICULUM (3) Supervision of elementary and secondary science teachers as they develop K-12 programs in the public schools. Prerequisites: 6 credits in science methods, 20 credits in science or equivalent, and teaching experience.

557. (Biol. 557) WORKSHOP IN THE BIOLOGICAL SCIENCES (3) Projects designed for teachers of biology in the secondary schools.

558. RESEARCH PROBLEMS IN SCIENCE TEACHING (3) Problems and research dealing with curriculum, materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sci.Ed. 458 or 459, and teaching experience.

559. ANALYSIS OF INSTRUCTION IN ELEMENTARY SCIENCE EDUCATION (3) Analysis of the history, issues, trends, and research in elementary science education. Prerequisites: teaching experience, 3 credits in elementary science methods, and 18 credits of science courses.

SOCIAL STUDIES EDUCATION (SS ED)

430. TEACHING SOCIAL STUDIES IN THE ELEMENTARY GRADES (2-3)

431. TEACHING SOCIAL STUDIES IN THE SECONDARY SCHOOLS (4)

432. THE SOCIAL SCIENCES IN THE SOCIAL STUDIES CURRICULUM (2-3)

470. ISSUES IN SOCIAL STUDIES EDUCATION (1-6)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

530. INSTRUCTIONAL PRACTICES IN THE SOCIAL STUDIES (3) Social studies innovations in the classroom, new programs, new materials, new methods, and evaluation. Prerequisite: one year of teaching experience.

532. RESEARCH PROBLEMS IN SECONDARY SCHOOL SOCIAL STUDIES (3) Rationale of the social studies curriculum for the middle and high school. Promising social studies programs for the adolescent. Prerequisites: a methods course in social studies and teaching experience.

533. RESEARCH IN THE TEACHING OF SOCIAL STUDIES (3) Procedures and methods of research for the teaching of social studies, strategies of investigation and review of research literature. Prerequisites: 12 credits in the social sciences on the 400 or 500 level and teaching experience.

DAIRY SCIENCE (D SC)

E. M. KESLER, *Chairman, Graduate Program in Dairy Science*
205 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Almquist, Amann, Baumgardt, Flipse, Hargrove, Kesler, McCarthy, Muller, Patton, and Tanabe.

Graduate Faculty: Associate Members Buckalew, Shellenberger, Specht, and Thoele.

Students may specialize in dairy cattle nutrition, metabolism, dairy cattle genetics, dairy cattle management, and physiology of reproduction. A minor program generally is taken in agricultural economics, animal nutrition, biochemistry, genetics, physiology, or statistics. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language or communication skills.

Prerequisite to graduate work is the completion of an undergraduate major in animal industry, animal science, dairy science, or a related area. The undergraduate program must include mathematics and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests. The Graduate Record Examination is required of all applicants.

DAIRY SCIENCE (D SC)

- 410. DAIRY HERD MANAGEMENT (4) *Muller*
- 423. ADVANCED DAIRY CATTLE JUDGING (1 per term, maximum of 2)
- 427. MILK SECRETION (3) *Kesler*
- 431. PHYSIOLOGY OF REPRODUCTION IN FARM ANIMALS (3) *Amann*
- 490. COLLOQUIUM (1)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 507. DAIRY CATTLE MANAGEMENT (1-6)
- 511. DAIRY CATTLE NUTRITION (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr.
- 401. *Kesler*
- 512. ADVANCED STUDIES IN MILK SECRETION (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Kesler*
- 513. DAIRY CATTLE BREEDING (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: An.Sc. 322, Biol. 422, 3 credits in statistics. *Hargrove*
- 515. ADVANCED PHYSIOLOGY OF REPRODUCTION IN FARM ANIMALS (1-6) *Almquist*
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

DEVELOPMENTAL AND REMEDIAL READING (D R R)

CAROL A. CARTWRIGHT, *In Charge of Graduate Program in Developmental and Remedial Reading*
155 Chambers Building

Degree Conferred: M.Ed.

Graduate Faculty: Senior Members Askov, Bliesmer, Cartwright, M. Dupuis, Fagan, Golub, Heilman, and Madsen.

The purpose of the master's program is to prepare classroom teachers in elementary and secondary schools for more effective teaching of reading and to provide preparation for supervisory and administrative positions relative to reading in school systems.

Candidates for a master's degree must meet the requirements for admission to graduate study and, in addition, (1) must hold, or be eligible to hold, a valid teaching certificate (persons not meeting this criterion may work on overcoming deficiencies; graduate credit, but not degree credit, may be received for graduate courses taken to overcome such deficiencies) and (2) must have had at least one year of teaching experience or the equivalent.

The master's program has been planned so that those completing the program will also meet the state requirements for "reading specialist" certification.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Detailed descriptions of courses available in reading may be found under Reading, Communication, and Language Education: RCLEd. 405, 420, 440, 446, 450, 526, 540, 545, 550, 551, 557, 596, 597.

EARTH SCIENCES (EARTH)

E. WILLARD MILLER, *Chairman of the Committee on Earth Sciences*
101 Mineral Sciences Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Blackadar, Cuffey, Dachille, de Pena, Dutton, Hosler, Lavin, Lewis, Miller, Panofsky, Thomson, Thornton, Traverse, Wernstedt, Williams, and Wright.

Graduate Faculty: Associate Members Cahir, Olivero, and J. Pena.

The M.Ed. program is designed to meet the needs of science teachers in elementary and secondary schools. The earth science fields of study are geography, geological sciences (geology, geochemistry and mineralogy, or geophysics), and meteorology. The student selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a paper in that area. An additional 12 credits must be taken in the other two fields of earth sciences; or 6 credits may be taken in one of the earth science fields plus 6 credits in other science or engineering fields. Two education courses, C.&S. 400 and Sci.Ed. 558, are required as a minor.

Students with a 2.50 junior-senior average, 18 credits in education and related psychology, and 6 credits in earth science fields or other appropriate background will be considered for admission to the M.Ed. program. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. The M.Ed. program is not offered during the summer term.

The D.Ed. program is designed for secondary school and college science teachers. The course requirements are planned by the candidate's committee. A minimum of 60 credits must include one area of concentration within the earth sciences — geography, geological sciences (geology, geochemistry and mineralogy, or geophysics), or meteorology — plus courses from each of the other two earth science areas. A minimum of 15 credits each is required in professional education and in thesis research.

The thesis topic must be in one of the earth sciences. Three consecutive terms of residence are required for the D.Ed. degree. The student's D.Ed. committee shall normally consist of five members — two members from the area of concentration, one member from each of the other two earth science fields, and one member from education.

In order to enter the D.Ed. program a candidate should present evidence of competence at the baccalaureate level in one of the earth sciences (geography, geological sciences, or meteorology) or in an allied science curriculum. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.70 grade-point average will be made for students with special backgrounds, abilities, and interests.

EARTH SCIENCES (EARTH)

400. EARTH SCIENCES SEMINAR (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

500. EARTH SCIENCES RESEARCH (1-6) Relationships between the earth sciences revealed by theory, analytical methods, or a selected problem.

ECOLOGY (ECLGY)

FREDERICK M. WILLIAMS, *In Charge of Graduate Programs in Ecology*
327 Erwin W. Mueller Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baker, Bellis, Butler, Cooper, Cuffey, DeWalle, Dunson, George, Graves, Guber, Hower, Hutnik, Keener, Kim, Lindzey, MacCluer, Patil, Rothenbacher, Schein, Shipman, and F. Williams.

Graduate Faculty: Associate Members Arnold, Burris, Davis, Kurland, Pearson, Reimer, and Stephenson.

This intercollege program emphasizes the properties of ecosystems by focusing attention on interactions of single organisms, populations, and communities with their environment. It is designed to give students a basic understanding of ecological theory and is, therefore, complementary to other environmental programs which emphasize man's role in ecosystems.

The instructional program includes three graduate core courses in ecology, augmented by an additional integrated group of seminars and courses selected for each student by the committee, and a research project directed by the thesis adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. The nonthesis option is available for the M.S. degree, upon adviser discretion.

The program is administered by a committee drawn from faculty members in several departments and colleges of the University. This committee and its chairman are appointed by the dean of the Graduate School. The instructional staff is composed of participating faculty in those departments offering graduate courses in fields closely allied to ecology.

The committee appointed by the Graduate School for each candidate in ecology is selected from members of the program committee and faculty from the student's area of specialization. The committee has the responsibility for determining the course program and research acceptable in satisfying degree requirements.

Students meeting the admission requirements of the Graduate School will be considered up to the number of spaces available in selecting candidates in this program. Candidates should have a strong science background including chemistry, physics, and mathematics. Preparation in biological sciences is also desirable. Students with a unique background in another discipline which has potential value to original ecological work will be seriously considered.

Students are strongly urged to choose their research interests and initiate communication with the relevant faculty member(s) before applying for admission. This is especially crucial if the student is

seeking financial aid. Teaching and research assistantships are available only through the student's faculty adviser.

In addition to the formal application, the applicant should forward the following *directly to the program chairman*: (1) two or more letters of recommendation regarding the student's academic and professional promise; (2) a concise one-page statement describing the student's goals both within the program and in professional life; and (3) Graduate Record Examination scores including verbal, quantitative, and an advanced test. More specific inquiries may be directed to the program chairman.

Detailed descriptions of courses now available for students majoring in ecology may be found under the offerings of several departments: Anthy. 502, 523; Biol. 433, 434, 435, 436, 451, 480, 481, 516, 519, 544, 545, 546; C.E. 472, 579, 580; Cmp.Sc. 402; Ent. 416, 517, 535; E.R.M. 410, 413; For. 508, 517; Geol. 503; Geosc. 425, 426, 547; Meteo. 505; Micrb. 400, 413, 529; Phil. 512; P.Path. 424; Stat. 524; V.Sc. 401; Wildl. 446, 551.

ECOLOGY (ECLGY)

590. COLLOQUIUM (1-3)

ECONOMICS (ECON)

MONROE NEWMAN *Acting Head of the Department*
613 Kern Graduate Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Senior Members Budd, Farr, Feller, Herendeen, Hu, Klein, Lombra, Nelson, Newman, Prybyla, Riew, Robinson, Rodgers, Rozen, and Smith.

Graduate Faculty: Associate Members Benson, Dickinson, Feinberg, Fox, Friedrich, Mehra, Ott, Rosenberg, Stephenson, Wasylenko, Wentzler, and Witte.

Opportunities are available for concentration in the following fields: economic analysis, economic doctrines, economic development of developed areas, economic development of underdeveloped areas, economic fluctuations, income distribution, industrial organization, international economics, comparative economic systems, labor economics, money and banking, public finance, quantitative economics, statistics, and regional economics.

Students may also qualify for admission to the program in population issues, consisting of interdisciplinary course work with special emphasis on the economic, social, and geographic issues arising from the dynamics of population change.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by any of the following alternatives: (1) a reading knowledge of two foreign languages, (2) a reading knowledge of one foreign language and 6 credits of other course work from designated areas which increase research skills, (3) the equivalent of 12 credits of departmentally approved course work which increases research skills, or (4) a comprehensive knowledge of one foreign language. The nonthesis option is available for the M.A. degree; a student choosing the program option in operations research must complete a thesis.

To enter graduate work in economics a student should have completed at least 18 undergraduate credits in the fields of economics, accounting, commerce, and business statistics, including at least 6 credits in economics. All applicants must take the Graduate Record Examination in advanced economics and general aptitude.

Students with a 2.50 junior-senior average, a 3.00 average in courses in economics, and appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.A. degrees (see p. 238).

ECONOMICS (ECON)

- 400. HISTORY OF ECONOMIC THOUGHT I (3)
- 401. HISTORY OF ECONOMIC THOUGHT II (3)
- 404. CURRENT ECONOMIC ISSUES (3)
- 405. ADVANCED ECONOMIC ANALYSIS (3)
- 412. LABOR MARKETS AND COLLECTIVE BARGAINING (3)
- 413. (L.S. 413) COMPARATIVE LABOR MOVEMENTS (3)
- 414. (L.S. 414) THEORIES OF THE LABOR MOVEMENT (3)
- 415. ECONOMICS OF INCOME MAINTENANCE (3)
- 423. STATE AND LOCAL TAXATION (3)
- 424. URBAN ECONOMICS (3)
- 425. ECONOMICS OF PUBLIC EXPENDITURES (3)
- 427. (Ed. Adm. 427) ECONOMICS OF EDUCATION (3)
- 428. ENVIRONMENTAL ECONOMICS (3)
- 429. ADVANCED PUBLIC FINANCE (3)
- 433. INTERNATIONAL MONETARY ECONOMICS (3)
- 442. MONOPOLY, COMPETITION, AND THEIR REGULATION (3)
- 445. (H.P.A. 445) HEALTH ECONOMICS (3)
- 450. THE BUSINESS CYCLE (3)
- 451. MONETARY THEORY AND POLICY (3)
- 461. ECONOMIC GROWTH: UNDERDEVELOPED AREAS (3)
- 462. ECONOMIC GROWTH: THEORIES OF UNITED STATES DEVELOPMENT (3)
- 463. ECONOMIC DEMOGRAPHY (3)
- 480. MATHEMATICAL ECONOMICS (3)
- 489. HONORS THESIS (3-6)
- 490. INTRODUCTION TO ECONOMETRICS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 499. FOREIGN STUDY IN ECONOMICS (2-6)

- 500. ECONOMIC SEMINAR (3-6)

- 502. MICROECONOMIC ANALYSIS (3) Economic behavior under pure and imperfect competition; price and output determination in product markets; prices and employment in factor markets.
- 503. MACROECONOMIC ANALYSIS (3) National income accounts; determination of income, employment, interest rates, and the price level; stabilization policy.
- 506. PROBLEMS IN ECONOMICS (1-12) Planned projects involving library, laboratory, or field work.
- 507. INTERNATIONAL TRADE (3) A survey of international trade theory including modern developments of pure theory, and of international trade policy.
- 508. CURRENT MONETARY THEORY AND POLICY (3) Post-Keynesian reformulation of quantity and Keynesian theories of money; liquidity and general equilibrium approaches; current issues in theory and policy.
- 510. ECONOMETRICS (3-6) Statistical estimation in mathematically formulated economic relationships.
- 513. DEVELOPMENT OF ECONOMIC DOCTRINES (3-6)
- 515. ECONOMICS OF THE LABOR MARKET (3) Theory and problems of labor-management relations; selected problems of the labor market with reference to current research and developments.
- 516. ECONOMICS OF HUMAN RESOURCES (3) Analysis of changes in human resource supply and demand; factors affecting these changes; current human resource policies.
- 517. INTERNATIONAL FINANCE (3) Problems of international liquidity; balance of payments adjustment; international financial institutions and selected policy problems.

518. DEVELOPMENT OF MONETARY THEORY (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.
519. (Mn.Ec. 519) MINERAL POLICY ANALYSIS (3) Principles of policy analysis; cost-benefit and other analytical techniques; environmental analyses; case studies of legislative and administrative mineral policy issues.
521. ADVANCED MICROECONOMIC THEORY (3-6) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.
522. ADVANCED MACROECONOMIC THEORY (3-6) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.
524. INCOME DISTRIBUTION (3) Measurement of inequality; ethical issues in income redistribution; measurement and determination of distributive shares; problem of poverty.
525. ECONOMICS OF TECHNOLOGICAL CHANGE (3) Theoretical and empirical analysis of invention and innovation and their effects on productivity, employment, and market structure.
529. PUBLIC FINANCE (3-6) Contemporary problems in public finance; instruments of fiscal policy in the achievement of full employment, price stability, and economic development.
530. REGIONAL MICROECONOMICS (3) Theoretical and empirical analysis of industrial location as determined by costs, markets, and agglomeration effects.
531. REGIONAL MACROECONOMICS (3) Aggregate regional trade flows; sources of regional economic data; techniques for measuring regional economic activity; long-run regional growth.
543. INDUSTRIAL ORGANIZATION AND PUBLIC POLICY (3) The structure of American industry; performance and behavior; public policies toward business.
550. ECONOMIC FLUCTUATIONS (3) Analysis of the various theories of economic fluctuations; their methodological premises.
551. STABILIZATION POLICY (3) Description and analysis of the alternatives and issues in stabilization policy.
560. SEMINAR IN ECONOMIC GROWTH: UNDERDEVELOPED AREAS (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.
561. SEMINAR IN ECONOMIC GROWTH: DEVELOPED AREAS (3-6) Growth models; strategic factors in growth; quantification problems; public policy.
571. COMPARATIVE ECONOMIC SYSTEMS (3-6) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision making and control.
572. SOVIET AND OTHER CENTRALLY PLANNED ECONOMIES (3-6) Principles, structure, and performance of centrally planned economies with special emphasis on the Soviet Union.
580. MATHEMATICAL ECONOMICS (3-9) Mathematical development of static and dynamic economic models: partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: Econ. 480.
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

G. P. CARTWRIGHT, *In Charge of Graduate Programs in Education of Exceptional Children*
307 CEDAR Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members C. Cartwright, G. Cartwright, French, Moores, Neisworth, and Salvia.

Graduate Faculty: Associate Members Gajar and Sindelar.

Exceptional children are those who deviate so far from average in physical, intellectual, emotional, or social characteristics that they cannot profit adequately from the usual public school program. It is the purpose of this program to prepare teachers, researchers, administrators, and college and university teachers in the areas encompassing the education of the mentally retarded, gifted, emotionally disturbed, neurologically impaired, or learning disabled. A multidisciplinary approach is emphasized. The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages.

Prerequisites for a master's program include: 24 credits basic to the education of exceptional children (courses comparable to RCLEd. 440; E.E.C. 400, 401, 403, 454; E.E.C. 410 or 430 or 470; Mth.Ed. 420; a 400-level course in child development or child psychology; and a 400-level course in foundations of education).

Highest admission priorities are given to applicants who possess certification in special education or elementary education. Applicants for master's and doctoral programs must present evidence of superior academic achievement and aptitude, complete a personal statement, present GRE verbal and quantitative test scores, and provide professional references. Applicants for doctoral study must have had at least two years of relevant experience with handicapped children. Applicants from foreign countries must submit TOEFL scores.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

- 400. INTRODUCTION TO EXCEPTIONAL CHILDREN (3)
- 401. EDUCATIONAL ADJUSTMENTS FOR EXCEPTIONAL CHILDREN (3)
- 403. CLINICAL TEACHING WITH EXCEPTIONAL CHILDREN (3)
- 405. PRACTICUM IN THE EDUCATION OF EXCEPTIONAL CHILDREN (1-12)
- 410. THE MENTALLY RETARDED (3)
- 411. INSTRUCTION FOR THE SEVERELY MENTALLY RETARDED (2)
- 412. INSTRUCTION FOR MILDLY HANDICAPPED CHILDREN (2)
- 413. (Vo.Ed. 413v) VOCATIONAL EDUCATION FOR SPECIAL-NEEDS LEARNERS (3)
- 420. THE MENTALLY GIFTED (3)
- 430. LEARNING DISABILITIES (3)
- 440. (S.P.A. 440) SURVEY OF SPEECH AND HEARING DISORDERS (3)
- 454. DIAGNOSIS OF EDUCATIONAL DISABILITIES (3)
- 460. EDUCATION OF VISUALLY HANDICAPPED CHILDREN (1)
- 470. THE EMOTIONALLY DISTURBED (3)
- 472. EDUCATIONAL PROBLEMS OF ALIENATED YOUTH (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

500. SEMINAR IN SPECIAL EDUCATION (1-9) Continuing series of professional seminars designed to provide a forum for discussion of current and classical research concerning exceptional children. Prerequisites: Ed.Psy. 400 and 6 credits in education of exceptional children.

501. ADMINISTRATION AND SUPERVISION OF EDUCATIONAL PROGRAMS FOR EXCEPTIONAL CHILDREN (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisites: E.E.C. 401 and Ed.Adm. 480, or teaching or administrative or supervisory experience.

502. **INTERNSHIP IN SPECIAL EDUCATION (2-10)** Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty. Prerequisite: E.E.C. 405 or teaching experience.
505. **PRACTICUM (1-6)** Supervised clinical experience on campus in University-managed diagnostic and remedial settings.
506. **FIELD EXPERIENCES IN OFF-CAMPUS LABORATORIES (1-10)** Supervised off-campus field experiences in selected laboratory settings with exceptional children. Prerequisite: E.E.C. 505.
507. **INTERNSHIP IN SPECIAL EDUCATION SUPERVISION (1-6)** Internship in day/residential school setting under supervision of field supervisor and University faculty. Prerequisite: E.E.C. 506.
509. **PROBLEMS, PROJECTS, AND AREA STUDIES IN SPECIAL EDUCATION (1-9)** May not be used for thesis credit. Prerequisite: 12 graduate credits in special education.
510. **PROBLEMS IN THE EDUCATION OF THE MENTALLY RETARDED (2-4)** Study of existing curriculums, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience and E.E.C. 410.
520. **PROBLEMS IN THE EDUCATION OF THE MENTALLY GIFTED (2-4)** Analysis of educational needs of the mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience and E.E.C. 420.
530. **PROBLEMS IN THE EDUCATION OF THE LEARNING DISABLED (2-4)** Review of the research and theoretical implications in the educational and behavioral management of learning disabled children. Prerequisite: E.E.C. 430.
545. (S.P.A. 545) **CEREBRAL PALSY (3)** Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multiprofessional habilitative program. Prerequisite: S.P.A. 444.
547. (S.P.A. 547) **LANGUAGE DISORDERS IN CHILDREN (2)** Nature, etiology, diagnosis, and management of language disorders in children. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.
554. **PSYCHOLOGICAL AND EDUCATIONAL EVALUATION OF EXCEPTIONAL CHILDREN (3)** Administration and interpretation of individual tests other than the Stanford-Binet, WISC, WAIS. Prerequisite: Psy. 559.
570. **PROBLEMS IN THE EDUCATION OF THE EMOTIONALLY DISTURBED (2-4)** Prerequisite: E.E.C. 470.
572. **SEMINAR IN THE EDUCATION OF ALIENATED GROUPS (2)** A study of the alienated and educational issues of coping with problems of social, cultural, and economic deprivation. Prerequisite: E.E.C. 472.
573. **PROBLEMS OF RESEARCH WITH ALIENATED GROUPS (2)** A seminar to review and design research studies for the education and training of alienated groups. Prerequisites: E.E.C. 472, 572.
596. **INDIVIDUAL STUDIES (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

EDUCATIONAL ADMINISTRATION (EDADM)

PATRICK D. LYNCH, *In Charge of Graduate Programs in Educational Administration*
318 Rackley Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Caldwell, Johnson, Lutz, Lynch, and Willower.

Graduate Faculty: Associate Members Fraser and Gipp.

Professional preparation programs are offered at the master's and doctoral degree levels for elementary and secondary school personnel whose objectives are to become prepared in education policy-making positions such as principals, supervisors, superintendents, intermediate unit officials, state and federal education agency personnel, professors of educational administration, or researchers in educational administration.

All candidates who seek M.Ed. and M.S. degrees in educational administration shall complete programs embracing a minimum of 30 graduate credits. Only in rare instances, however, to fulfill unusual objectives, will candidates be permitted to work toward the M.S. degree. In Pennsylvania a certification program consisting of at least 45 credits is required before one can become a public school administrator. Courses may be taken at the Capitol Campus; however, admission to the M.Ed. program must be approved by the University Park program chairman.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign and native American languages.

Candidates for the D.Ed. and Ph.D. degrees are required to complete a minimum of three consecutive terms during a calendar year in residence.

From the time of initiation of a 600-level thesis research program, all doctoral candidates shall continuously register (at least three terms per calendar year) until the termination of the graduate program. Failure to register for doctoral thesis credits in three out of four terms shall be considered automatic withdrawal. Specific requirements with respect to the Ph.D. and D.Ed. degrees may be learned from a departmental bulletin that is available upon request and from additional information on pages 70-76 of this catalog. Although candidates are required to specialize in a field of educational administration, they are encouraged to acquire a background in the social sciences and the humanistic foundations.

Requirements for admission to a graduate program in educational administration ordinarily include 18 approved undergraduate credits in education and psychology. All applicants for any graduate program, including certification, must submit either a Miller Analogies Test or Graduate Record Examination (quantitative and verbal) score. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Students with a 2.60 junior-senior average and with appropriate course backgrounds will be considered for admission to a master's program. Exceptions to the minimum 2.60 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

EDUCATIONAL ADMINISTRATION (EDADM)

- 427. (Econ. 427) ECONOMICS OF EDUCATION (3)
- 460. (Hi.Ed. 460) INTRODUCTION TO ADULT EDUCATION (3)
- 480. EDUCATIONAL ADMINISTRATION (2-3)
- 481. COLLECTIVE NEGOTIATIONS IN PUBLIC EDUCATION (3)

- 525. FEDERAL EDUCATION POLICIES (3) Analysis of federal role in development of educational policy and its relationship to state and local policy.
- 528. POLITICS AND EDUCATION (3) Social forces which shape the educational system and determine national, state, and local educational policies.
- 533. THE POLITICS OF LOCAL SCHOOL DISTRICTS (3) The methodology of studying political decision making and the theory and practice of politics in local school districts. Prerequisite: 6 credits of sociology, anthropology, or political science.
- 560. SYSTEM THEORY IN EDUCATION (3) Concepts of general system theory, the systems approach, and related methodologies and tools; applications in education; critique of instructional systems. Prerequisites: Ed.Psy. 400, 475.
- 565. PERSONNEL AND GRIEVANCE ADMINISTRATION (2-3) Practice and theory of personnel supervision at the central office and building level, including contract administration and grievance handling. Prerequisites: 18 credits in education and three years' teaching experience.

567. **ORGANIZATIONAL SUPERVISION (3)** The organizational context of the school, its relationship to supervision, and the improvement of instruction. Prerequisites: Ed.Adm. 480 and teaching experience.
568. **THE PRINCIPALSHIP (2-3)** For elementary and secondary principals. The administrative and management tasks of building administration. The social system, change, and community relationships.
569. **PRINCIPALSHIP SEMINAR (2-3)** The study and application of interdisciplinary-based products and processes in the various organizational units within the educational system.
571. **THE EDUCATIONAL PLANT (2-3)** School plant needs in terms of school population and curricula; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventilation, equipment, school building costs and finance. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
572. **ANALYSIS OF SCHOOL-COMMUNITY RELATIONS (2-3)** School-community relationships; social structure, social change, and the schools; case studies of community-school problems. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
573. **PUBLIC SCHOOL FINANCE (2-3)** Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money management. Prerequisite: Ed. Adm. 480 or teaching or administrative or supervisory experience.
574. **THEORY AND PRACTICE OF EDUCATIONAL NEGOTIATIONS (2-3)** Theoretical framework, bargaining strategies, legislation, administrative roles, agreements, etc. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience, and previous work in school administration.
575. **(Hi.Ed. 575) ADMINISTRATION OF ADULT EDUCATION (3)** The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
576. **LEGAL ASPECTS OF SCHOOL ADMINISTRATION (3)** Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies, the course of study, textbooks; contracts; taxes, torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
577. **ECONOMIC DIMENSIONS OF EDUCATIONAL ADMINISTRATION (3)** Application of selected economic concepts and tools of analysis to administrative decision and planning processes in educational systems. Prerequisite: Ed.Adm. 480.
578. **SCHOOLS AS ORGANIZATIONS (2-3)** Intraorganizational relationships; administration and the school as a social system; formal and informal organization. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
579. **PUBLIC SCHOOL BUSINESS ADMINISTRATION (2-3)** Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience; Ed.Adm. 573.
580. **THE USE OF THEORY IN EDUCATIONAL ADMINISTRATION (1-6)** Administrative theories applied to educational organizations. Prerequisites: Ed.Adm. 480; 6 credits in educational administration.
581. **FIELD RESEARCH IN EDUCATIONAL ADMINISTRATION (2-3)** The use of field study methods in educational research and evaluation, and of participant observation in administration practice. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.
582. **INTERNSHIP IN ADMINISTRATION AND SUPERVISION (1-12)** Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

583. SUBSTANTIVE ISSUES IN SCHOOL LAW (3) Focuses on substantive law in such areas as academic freedom, student records, teacher rights and responsibilities, and desegregation. Prerequisite: Ed.Adm. 576.

588. WORKSHOP IN CURRENT EDUCATIONAL PROBLEMS (1-6) For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

589. PROBLEMS, PROJECTS, AND AREA STUDIES IN EDUCATIONAL ADMINISTRATION (1-6) Independent work in the study of topics in educational administration, or development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

591. SEMINAR IN PUBLIC SCHOOL RESEARCH (1-4) Doctoral candidates present outlines of their theses to the graduate faculty of the department and advanced graduate students.

596. INDIVIDUAL STUDIES (1-6)

EDUCATIONAL PSYCHOLOGY (EDPSY)

JOSEPH FRENCH, *In Charge of Graduate Programs in Educational Psychology*
403 Carpenter Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members DiVesta, French, Games, Marks, Mitzel, Rabinowitz, Roberts, Schwartz, Seibel, Thevaos, Tjosvold, Weener, and Withall.

Graduate Faculty: Associate Member Snyder.

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in school learning, educational and psychological measurement, statistics and research design as applied to education, and the evaluation of educational programs. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, school psychology, and special education, are offered in other departments of the University.

Doctoral degree requirements include a major emphasis in one of the above areas of educational psychology with minor emphasis in one other related area. The doctoral program of study includes a minimum of one course in each of the following areas: individual differences, psychological tests and measurement, statistics, experimental design, and learning from within the program; at least one course in developmental psychology, social psychology, and personality from the Department of Psychology; and at least one course in educational or philosophical foundations. In lieu of the foreign language requirement for the Ph.D. degree, students are expected to present to the committee a statement of objectives and goals and a plan of the academic and nonacademic work to be undertaken in achieving these goals. Within the context of the above, the students are expected to incorporate relevant experiences which are now part of the language and communication requirements, whether in course work, research, or teaching, to increase their effectiveness as educational psychologists.

Special facilities available to the department include a research design laboratory, rooms for conducting research projects, facilities for film production and editing, and a closed-circuit television studio used for both research and instruction. Other facilities available to students majoring in educational psychology are the Nursery School, the Psychology Clinic, the Reading Center, the Center for Educational Diagnosis and Remediation, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with several computer systems, is available for use in graduate student research.

Students with a 3.00 junior-senior average and a broad undergraduate background including some college mathematics will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants

are required to submit scores on the Graduate Record Examination. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one-half of their graduate credits of A quality.

EDUCATIONAL PSYCHOLOGY (EDPSY)

- 400. INTRODUCTION TO STATISTICS IN EDUCATIONAL RESEARCH (3)
- 406. APPLIED STATISTICAL INFERENCE FOR THE BEHAVIORAL SCIENCES (3)
- 421. LEARNING PROCESSES IN RELATION TO EDUCATIONAL PRACTICES (3)
- 450. (Psy. 450) PRINCIPLES OF MEASUREMENT (3)
- 451. APPRAISAL AND INTERPRETATION OF STANDARDIZED GROUP TESTS (2)
- 475. INTRODUCTION TO EDUCATIONAL RESEARCH (2)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 506. ADVANCED TECHNIQUES FOR ANALYZING EDUCATIONAL EXPERIMENTS (3) Analytical and experimental control considerations for designs involving nested and/or crossed subjects. Analysis of variance and multiple comparisons via computers. Prerequisite: Ed.Psy. 406 or Psy. 415.
- 507. MULTIVARIATE PROCEDURES IN EDUCATIONAL RESEARCH (3) Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisite: Ed.Psy. 406 or Psy. 415.
- 512. GROUP PROCESSES IN THE CLASSROOM (2) Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.
- 513. INDIVIDUAL AND GROUP DIFFERENCES (2) Historical and contemporary attempts to relate individual differences to important social and educational issues. Prerequisite: Ed.Psy. 400 or Psy. 15.
- 518. CONTEMPORARY LEARNING MODELS IN EDUCATIONAL PSYCHOLOGY (3) Contemporary mathematical models and computer simulations of complex human learning occurring in school settings. Modes for analyzing the learning environment. Prerequisite: Ed.Psy. 421.
- 519. PSYCHOLOGICAL FOUNDATIONS FOR COLLEGE TEACHING (2) Psychological, sociological, and organizational variables which influence college student behavior. Designed for graduate students who anticipate careers in college teaching.
- 522. CONCEPT LEARNING IN THE SCHOOLS (2) Study of theory and research related to concept formation and attainment with implications for instruction. Prerequisite: Ed.Psy. 421.
- 523. PROBLEM SOLVING IN THE SCHOOLS (2) Examination of theory and research related to cognitive processes in problem solving with implications for educational practice. Prerequisite: Ed.Psy. 421.
- 524. THEORIES OF LEARNING AND INSTRUCTION (3) Study of major classical theories of learning and recent developments in learning and instructional theory. Prerequisite: Ed.Psy. 421.
- 526. (RCLEd.526) THE PSYCHOLOGY OF READING (3) Psychological principles underlying the process of reading and comprehending with application to instruction. Prerequisite: Ed. Psy. 421.
- 550. DESIGN AND CONSTRUCTION OF PSYCHOLOGICAL MEASURES (3) Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive validity. Prerequisite: Ed.Psy. 450.
- 554. THEORIES OF PSYCHOLOGICAL MEASUREMENT (2) Basic true-score and error models; their extensions to test reliability and test validity; problems of item analysis and weighting. Prerequisite: Ed.Psy. 450.
- 575. SEMINAR IN EDUCATIONAL PSYCHOLOGY (3-9) A seminar dealing with specific topics in educational psychology. Open to advanced students in the behavioral sciences.

- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

ELECTRICAL ENGINEERING (E E)

WILLIAM J. ROSS, *Head of the Department*
118 Electrical Engineering East

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Adams, Bredeson, Brown, Cross, Das, Etzweiler, Ferraro, Geselowitz, Hale, Lachs, Lee, Lewis, McMurtry, Nisbet, Ross, Trutt, and Young.

Graduate Faculty: Associate Members Carpenter, Delansky, Hulina, Mathews, Robinson, Stach, Stein, Symons, and Voltmer.

The principal areas of graduate research are in ionospheric studies, solid state electronics, computers and digital systems, and power systems. Course offerings support these research areas as well as work in automatic control, biomedical engineering, communications, electromagnetics, network and system theory, plasmas, and quantum electronics.

The requirements for the M.S. degree may be satisfied through (1) a thesis option where the program includes a minimum of 24 course credits plus 6 thesis credits and the submission of an approved thesis, or (2) a nonthesis option where 30 course credits are required, together with the preparation of a scholarly report and the passing of an M.S. examination. No foreign language is required.

The communication and foreign language requirement for the Ph.D. degree does not specify a foreign language, but the candidate is required to demonstrate both written and oral proficiency in English.

To be admitted to the M.S. program without undergraduate deficiencies, a B.S. degree in electrical engineering from an accredited program, or its equivalent, is required with appropriate courses in electrical circuits, fields, and electronics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

ELECTRICAL ENGINEERING (E E)

- 405. ELECTRONIC INSTRUMENTATION FOR NONELECTRICAL ENGINEERS AND SCIENTISTS (3)
- 406. ELECTRICAL POWER GENERATION AND TRANSMISSION (3)
- 411. PRINCIPLES OF ELECTROMAGNETIC FIELDS (3)
- 413. LINEAR NETWORK ANALYSIS (3)
- 414. PRINCIPLES AND APPLICATIONS OF LASERS AND MASERS (3)
- 417. SYSTEM THEORY (3)
- 418. SOLID STATE DEVICE TECHNOLOGY (3)
- 419. SOLID STATE DEVICES (3)
- 423. FUNDAMENTALS OF INDUSTRIAL ELECTRONICS (3)
- 424. FUNDAMENTALS OF ELECTRICAL DESIGN (3)
- 425. SYMMETRICAL COMPONENTS (3)
- 428. LINEAR CONTROL SYSTEMS (3)
- 432. UHF AND MICROWAVE ENGINEERING (3)
- 438. ANTENNA ENGINEERING (3)
- 441. ACTIVE CIRCUITS (3)
- 448. LINEAR ELECTRONIC DESIGN (3)
- 449. DIGITAL ELECTRONIC DESIGN (3)

- 450. NETWORK ANALYSIS (3)
- 458. DATA COMMUNICATION (3)
- 459. INTRODUCTION TO STATISTICAL THEORY OF COMMUNICATIONS (3)
- 461. FUNDAMENTALS OF POWER SYSTEM STABILITY (3)
- 470. ELECTRONIC ANALOG COMPUTERS (3)
- 471. LOGICAL DESIGN OF SWITCHING SYSTEMS (3)
- 472. DIGITAL SYSTEMS (3)
- 473. DIGITAL SYSTEMS LABORATORY (3)
- 475. INTRODUCTION TO HYBRID COMPUTATION (3)
- 477. SYNTHESIS AND DESIGN OF ELECTRICAL SYSTEMS (3)
- 490. (Nuc.E. 490) INTRODUCTION TO PLASMAS (3)
- 492. (Astro. 492) SPACE ASTRONOMY AND INTRODUCTION TO SPACE SCIENCE (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 519. SEMICONDUCTOR DEVICES (3) Characteristics and limitations of bipolar transistors, diodes, transit time and bulk-effect devices. Prerequisite: E.E. 419.
- 521. ADVANCED ELECTRICAL ENGINEERING PROBLEMS (1-10)
- 527. LINEAR CONTROL SYSTEMS (3) Continuous and discrete-time linear control systems; state variable models; analytical design for deterministic and random inputs; time-varying systems stability. Prerequisites: E.E. 428 or M.E. 455; E.E. 417.
- 528. NONLINEAR CONTROL AND STABILITY (3) Design of nonlinear automatic control systems; phase-plane methods; describing functions; optimum switched systems; Liapunov stability; special topics in stability. Prerequisites: E.E. 428 or M.E. 455; E.E. 417.
- 529. OPTIMAL CONTROL (3) Variational methods in control system design; classical calculus of variations, dynamic programming, maximum principle; optimal digital control systems; state estimation. Prerequisite: E.E. 527.
- 530. ADAPTIVE AND LEARNING SYSTEMS (3) Adaptive and learning control systems; system identification; performance indices; gradient, stochastic approximation, controlled random search methods; introduction to pattern recognition. Prerequisite: E.E. 527.
- 535. ENGINEERING ANALYSIS (3) Applications of mapping methods, series and integral representations to the solution of boundary value problems in electrical engineering.
- 540. (Nuc.E. 540) THEORY OF PLASMA WAVES (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: E.E. 490.
- 541. (Nuc.E. 541) PLASMA THEORY (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: E.E. 540 (Nuc.E. 540).
- 546. FIELD-EFFECT DEVICES (3) The physical background, characteristics and limitations of surface field-effect and junction field-effect devices and related structures. Prerequisite: E.E. 419.
- 547. DIELECTRIC DEVICES (3) Applications of insulator physics and devices based on insulator properties. Prerequisite: E.E. 419.
- 548. LINEAR INTEGRATED CIRCUITS (3) Design of monolithic, thin-film and hybrid linear integrated circuits; D.C., video, tuned, r.f., and microwave applications. Emphasis on reliability. Prerequisites: E.E. 418, 448.
- 550. NETWORK SYNTHESIS (3) Positive real functions, realizability conditions, synthesis of driving point immittances, synthesis of two-terminal pair networks, transfer function synthesis. Prerequisite: E.E. 450.
- 560. STATISTICAL THEORY OF COMMUNICATIONS (3) Generalized harmonic analysis; the application of correlation and convolution to the detection of signals in noise; various special topics. Prerequisite: E.E. 459 or Math. 409.

561. **INFORMATION THEORY (3)** Mathematical measurement of information; information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems. Prerequisite: E.E. 459 or Math. 409.

562. **DETECTION THEORY (3)** Detection decision theory, Bayes and Neyman-Pearson criteria, optimal receivers, classical estimation theory, signal-noise representations, optimum linear signal parameters estimation. Prerequisite: E.E. 560.

569. **SIMULATION OF BIOMEDICAL SYSTEMS (3)** Simulation of biological and medical systems on analog and digital computers; direct electrical analogs; modeling techniques. Prerequisites: E.E. 470; Biol. 11.

570. **ADVANCED ELECTRONIC ANALOG COMPUTERS (3)** Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.

571. **DIGITAL COMPUTERS: RECENT DEVELOPMENTS AND ADVANCED LOGIC (3)** Advanced treatment of logical design; discussion of topics of current interest in the general area of digital computers. Prerequisite: E.E. 471.

572. **DIGITAL SYSTEM DESIGN (3)** Complete digital system design including specification, internal organization, and realization. Discussion of interaction among digital systems and subsystems. Prerequisite: E.E. 472.

573. **FAULT DETECTION IN DIGITAL CIRCUITS (3)** Advanced treatment of fault detection, location and redundancy techniques. Prerequisite: E.E. 471.

580. **RADIO WAVES AND THE IONOSPHERE (3)** The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 62 or 438 or Phys. 557.

581. **CONSTITUTION OF THE IONOSPHERE (3)** Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

ENGINEERING MECHANICS (E MCH)

JOHN R. MENTZER, *Head of the Department of Engineering Science and Mechanics*
227B Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Conway, Fenlon, Fonash, Hayek, Haythornthwaite, Hu, Kiusalaas, Llorens, Mentzer, Neubert, Queeney, Sharma, Thompson, and Zamrik.

Graduate Faculty: Associate Members Ashok, Petersen, and Pytel.

Graduate programs in engineering mechanics emphasize fundamental knowledge and include research opportunities in theoretical and experimental mechanics, with a primary focus on the mechanics and physics of solids.

Graduate study is available in continuum mechanics, structural mechanics, dynamics, vibrations and acoustics, biomechanics, micromechanics, experimental mechanics, and properties of materials. Thesis work in these areas is frequently directed toward specific applications of technological interest in biosystems, geosystems, energy production and distribution, materials engineering, and structural design.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Programs leading to a minor in engineering mechanics are available for doctoral students who seek to complement their studies in their major fields by acquiring a broader background in theoretical and experimental mechanics.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Other course offerings of the department are listed under *Other Graduate Courses*.

ENGINEERING MECHANICS (E MCH)

- 400. ADVANCED STRENGTH OF MATERIALS AND DESIGN (3) *Hu*
- 401. DESIGN AND SYNTHESIS IN VIBRATIONS (3) *Hayek*
- 402. APPLIED AND EXPERIMENTAL STRESS ANALYSIS (3) *Conway*
- 403. STRENGTH DESIGN IN MATERIALS AND STRUCTURES (4) *Queeney*
- 407. COMPUTER METHODS IN ENGINEERING DESIGN (3) *Kiusalaas*
- 408. ELASTICITY AND ENGINEERING APPLICATIONS (3) *Kiusalaas*
- 409. ADVANCED MECHANICS (3) *Pytel*
- 410. MECHANICS OF SPACE FLIGHT (3) *Pytel*
- 412. EXPERIMENTAL METHODS IN VIBRATIONS (3) *Neubert*
- 413. PLASTIC ANALYSIS OF STRUCTURES (3) *Haythornthwaite*
- 414. ELEMENTS OF MATERIAL SCIENCE (3) *Queeney*
- 415. FRACTURE MECHANICS (3) *Queeney*
- 421. CONTINUUM MECHANICS (3) *Hu and Pytel*
- 422. CONTINUUM MECHANICS (3) *Hu*
- 446. MECHANICS OF VISCOELASTIC MATERIALS (3) *Sharma*
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

500. ADVANCED MECHANICS OF MATERIALS (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-walled cylinders, shrink-fit assemblies, and rotating discs; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13. *Zamrik*

506. EXPERIMENTAL STRESS ANALYSIS (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507. *Conway*

507. THEORY OF ELASTICITY AND APPLICATIONS (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13. *Kiusalaas*

509. THEORY OF PLATES AND SHELLS (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13. *Kiusalaas*

514. ENGINEERING MECHANICS SEMINAR (1 per term) Current literature and special problems in engineering mechanics.

516. MATHEMATICAL THEORY OF ELASTICITY (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potential; applications. Prerequisite: E.Mch. 540. *Hayek*

520. ADVANCED DYNAMICS (3) Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12; Math. 72 or 431. *Pytel*

521. STRESS WAVES IN SOLIDS (3) Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact and numerical methods. Prerequisites: E.Mch. 12; Math. 432 or E.Mch. 524A and 524B.

522. **THEORY OF VIBRATIONS (3)** Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E.Mch. 13; Math. 72 or 431. *Neubert*
523. **COMPUTER METHODS IN ENGINEERING ANALYSIS (3)** Finite elements, finite differences, and matrix methods applied to dynamics, elasticity, wave propagation, heat conduction structural analysis, and fluid flow. Prerequisite: Math. 72. *Kiusalaas*
524. **MATHEMATICAL METHODS IN ENGINEERING (3 per unit)** *Hayek and Thompson*
Unit A (3) Basic tools, including Fourier, Legendre, and other orthogonal series, special functions, Laplace transforms. Applications in mechanics and other fields. Prerequisite: Math. 351.
Unit B (3) Solution techniques for boundary-value problems in curvilinear coordinates, integral transforms. Green's functions, potentials, applications to diffusion, vibration, wave-propagation. Prerequisite: E.Mch. 524A or Math. 431.
525. **VIBRATION AND SHOCK IN DAMPED MECHANICAL SYSTEMS (3)** Rubberlike materials; vibration isolation; structural impedance; wave propagation; multiforce excitation of beams; Timoshenko beams; transients; shock spectra; damage; nonlinear response. Prerequisite: E.Mch. 401 or 522.
526. **NONLINEAR MECHANICS (3)** Integral curves, singular points, self-sustained oscillations, stability problems, Hill's and Van der Pol's equation, mechanical and electrical application. Prerequisite: E.Mch. 522. *Neubert*
527. **STRUCTURAL DYNAMICS (3)** Dynamic behavior of structural systems; normal modes; input spectra; finite element representation of frameworks, plates, and shells; impedance; elastic-plastic response. Prerequisites: E.Mch. 12, 13. *Neubert*
528. **EXPERIMENTAL METHODS IN VIBRATIONS (3)** Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, nondestructive testing. Prerequisite: E.Mch. 401 or 522. *Neubert*
530. **SOLID STATE MECHANICS (3)** Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. *Hu*
531. **THEORY OF PLASTICITY AND APPLICATIONS (3)** Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 507. *Hu*
533. **DETERMINATION OF MECHANICAL PROPERTIES (3)** Experimental methods for determining hardness, elastic constants, creep behavior, fatigue strength, plastic flow, and dynamic properties of metals. Prerequisite: E.Mch. 530. *Zamrik*
534. **PHOTOELASTICITY (3)** Analysis of polariscopes; isoclinics, isochromatics, and stress trajectories; two- and three-dimensional photoelastic methods; determination of principal stresses; model preparation. Prerequisite: E.Mch. 408 or 507. *Conway*
535. (Metal. 535) **CRYSTAL DEFECTS AND MECHANICAL RESPONSE (3)** Mechanical responses of crystalline solids containing point, line, and interfacial defects; elastic and plastic responses. Prerequisite: Metal. 514 or E.Mch. 414. *Queeney*
540. **INTRODUCTION TO CONTINUUM MECHANICS (3)** Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics. *Hayek*
546. **THEORY OF VISCOELASTICITY AND APPLICATIONS (3)** Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E.Mch. 507. *Sharma*
550. **STUDIES IN ENGINEERING MECHANICS (1-6)** Studies in any field of engineering mechanics.
570. **RANDOM VIBRATIONS IN STRUCTURAL MECHANICS (3)** Probability theory applied to random vibrations of linear and nonlinear systems; excitation by ground motion, turbulence, and noise; acoustic damping. Prerequisite: Aersp. 411 or E.Mch. 401 or 522. *Neubert*

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

ENGINEERING SCIENCE (E SC)

JOHN R. MENTZER, *Head of the Department of Engineering Science and Mechanics*
227B Hammond Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members Conway, Fenlon, Fonash, Hayek, Haythornthwaite, Hu, Kiusalaas, Llorens, Mentzer, Neubert, Queeney, Sharma, Thompson, and Zamrik.

Graduate Faculty: Associate Members Ashok, Petersen, and Pytel.

This program is characterized by strong components in engineering analysis, the basic sciences, and areas of emerging technological importance. The program is interdisciplinary in structure with sufficient flexibility to allow a student to specialize in any of a variety of disciplines according to his or her professional objectives. The basic requirements of course work by subject area are as follows:

Engineering Analysis	— six credits
Materials	— six credits
Basic Sciences	— six credits
Engineering Sciences	— six credits

Within these guidelines, work in the listed areas may be arranged in consultation with the adviser to constitute a program of study to accommodate the objectives of the student, and it is expected that courses outside the department may constitute part of the content in the engineering sciences.

A thesis is required for the M.S. degree as part of the 30 credits required in the program.

Admission to the program requires a bachelor's degree in engineering or science from an accredited institution, with a junior-senior grade-point average of at least 2.50. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

This program should be distinguished from the graduate program in engineering science at Behrend, Capitol, and Radnor which offers the M.Eng. degree.

ENGINEERING SCIENCE (E SC)

- 400. ELECTROMAGNETIC FIELDS (3)
- 401. SENIOR DESIGN PROJECT (2)
- 402. SENIOR DESIGN PROJECT (2)
- 403. SENIOR DESIGN PROJECT (3)
- 404. ANALYSIS IN ENGINEERING SCIENCE (3)
- 405. ENGINEERING APPLICATIONS OF FIELD THEORY (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501. SOLID STATE ENERGY CONVERSION (3) Principles of solid state energy conversion and their utilization in engineering devices. Emphasis on current research and development efforts. Prerequisite: E.E. 419 or Phys. 412.

NOTE: *Other departmental courses are listed under Engineering Mechanics.*

ENGINEERING SCIENCE (E SC)

SABIH I. HAYEK, *Chairman of the Engineering Graduate Committee for Off-Campus Programs*
224 Hammond Building

Degree Conferred: M.Eng.

Behrend College — Richard C. Bollinger, *Director of Program*

Graduate Faculty: Associate Members Bollinger and Salvia.

Radnor Center for Graduate Studies — Helmut E. Weber, *Director of Program*

Graduate Faculty: Senior Member Weber.

Graduate Faculty: Associate Members Callahan, Duncan, Kozik, Llorens, and Stein.

Capitol Campus — Robert A. Conover, *Director of Program*

Graduate Faculty: Senior Members Bissinger, Conover, Dahir, Grenier, and Murty.

Graduate Faculty: Associate Members Cole, Ezard, Hartzler, Maynard, Miller, Rao, Shoup, Wade, and Welsh.

A program leading to the degree of Master of Engineering with a major in engineering science is offered at Behrend College, the Radnor Center for Graduate Studies, and at the Capitol Campus, near Harrisburg. Details of the program may be obtained by writing directly to these locations. Addresses are given in the front of this catalog.

The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of the student's major interest. It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area. Courses offered for the program are all established and controlled by the resident departments at the University Park Campus.

This program should be distinguished from the graduate program in engineering science at University Park which offers the M.S. degree.

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering which have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 30 credits is required, of which at least 12 must be at the 500 level. A scholarly written report is also required. Three of the above credits may be applied to this report.

Students may be admitted to the program from a wide variety of disciplines. Students applying for admission are expected to have completed the following core of courses: (1) physics through modern physics, (2) mathematics through differential equations, (3) one course in engineering thermodynamics, (4) one course in electrical circuits, and (5) basic courses in engineering statics and dynamics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details regarding admission requirements are available from the directors of the graduate centers offering the program.

ENGLISH (ENGL)

WENDELL V. HARRIS, *Head of the Department*
117 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Austin, Begnal, Borklund, Condee, Crane, Damerst, Harris, Hudspeth, R. Hume, Kiernan, Lewis, Lougy, Mann, Meserole, O'Donnell, Price, Rodgers, R. Secor, Smith, Walden, S. Weintraub, West, and Young.

Graduate Faculty: Associate Members Arnold, Balaban, Buck, Buckalew, Burns, Ebbitt, Eckhardt, Fitzgerald, Gidez, Grecco, K. Hume, Joukovsky, Kiffer, McAdams, Moore, Park, Rambeau, Rogers, Schneeman, Thigpen, Toth, and Trautmann.

A student may specialize in English literature, American literature, or philology. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If the student does not present 18 credits in English, deficiencies must be made up early in the graduate program. For the M.A. in English, a minimum of 33 graduate credits is required. A thesis is required of all M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be met by successful performance in any one of the following options: (1) critical and scholarly competence in one area of the literature of a foreign language; (2) reading, writing, and speaking knowledge of one foreign language; (3) reading knowledge of two foreign languages; or (4) reading knowledge of one foreign language and demonstrated competence (normally by successful course work) in a technique such as computer science, statistics, etc., where relevant to the student's research interest.

Students with a 3.30 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.30 grade-point average may be made for students with special backgrounds, abilities, and interests. Graduate Record Examination scores are required.

ENGLISH (ENGL)

- 406. HISTORY OF THE ENGLISH LANGUAGE (3)
- 407. HISTORY OF THE ENGLISH LANGUAGE FOR TEACHERS (3)
- 408. APPLIED ENGLISH LANGUAGE ANALYSIS (3)
- 410. RHETORICAL THEORY AND PRACTICE (3)
- 411. PROBLEMS OF STYLE (3)
- 412. THE WRITING OF FICTION (3-6)
- 413. VERSE WRITING (3-6)
- 414. BIOGRAPHICAL WRITING (3)
- 415. NONFICTION WRITING (3 per term, maximum of 6)
- 416. (Journ. 416) SCIENCE WRITING (3-6)
- 417. THE EDITORIAL PROCESS (3)
- 418. ADVANCED TECHNICAL WRITING AND EDITING (3-6)
- 430. MASTERS OF AMERICAN LITERATURE (3-6)
- 431. MOVEMENTS IN AMERICAN LITERATURE (3-6)
- 432. THE AMERICAN NOVEL TO 1900 (3)
- 433. THE AMERICAN NOVEL SINCE 1900 (3)
- 435. THE AMERICAN SHORT STORY (3)
- 437. AMERICAN POETRY (3)
- 438. AMERICAN DRAMA (3)
- 439. AMERICAN NONFICTION PROSE (3)
- 440. STUDIES IN BRITISH LITERATURE (3-6)
- 441. CHAUCER (3)
- 443. THE ENGLISH RENAISSANCE (3)
- 444. SHAKESPEARE: THE GENRES (3)

445. SHAKESPEARE'S CONTEMPORARIES (3)
 446. MILTON (3)
 451. THE RESTORATION AND THE EIGHTEENTH CENTURY (3)
 455. THE NOVEL IN ENGLAND TO JANE AUSTEN (3)
 460. THE ROMANTICS (3)
 464. THE VICTORIANS (3)
 465. VICTORIAN NOVEL (3)
 470. LITERATURE OF THE BRITISH COMMONWEALTH (3)
 475. MODERN BRITISH FICTION (3)
 477. MODERN POETRY (3)
 478. BRITISH AND IRISH DRAMA SINCE 1890 (3)
 484. (L.A. 484) COMPUTATIONAL AND QUANTITATIVE STYLISTICS (3)
 488. (C.Lit. 488) MODERN CONTINENTAL DRAMA (3)
 491. LITERATURE FOR TEACHERS IN SECONDARY SCHOOLS (3)
 492. HISTORY OF ENGLISH LITERARY CRITICISM (3)
 495. THE FOLKTALE IN AMERICAN LITERATURE (3)
 496. INDEPENDENT STUDIES (1-12)
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501. MATERIALS AND METHODS OF RESEARCH (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major.
 502. THEORY AND TEACHING OF COMPOSITION (3) Study of grammar, logic, rhetoric, and style in their applicability to teaching composition.
 506. THE ENGLISH LANGUAGE (3) A problem-centered approach to literary and oral forms of English, utilizing historical and analytic perspectives.
 512. THE WRITING OF FICTION (3-6) Supervised workshop in advanced techniques of writing fiction.
 513. THE WRITING OF POETRY (3-6) For the student with considerable experience in writing poetry; a workshop devoted to advanced poetic technique. Prerequisite: Engl. 413.
 520. THE MIDDLE ENGLISH ROMANCE (3) A detailed study of the Middle English metrical romance in terms of its milieu and its genre in the West.
 521. OLD ENGLISH LANGUAGE (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry.
 522. BEOWULF (3) Reading and critical analysis. Prerequisite: Engl. 521.
 523. WORDSWORTH AND COLERIDGE (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period.
 524. BYRON AND SHELLEY (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period.
 525. BLAKE AND KEATS (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period.
 526. TENNYSON AND BROWNING (3)
 536. HENRY JAMES (3) The development of James as critic, novelist, and short story writer.
 540. STUDIES IN ELIZABETHAN PROSE AND POETRY (3-6)
 541. MEDIEVAL STUDIES (3-6) Special problems in medieval English literature.
 542. MIDDLE ENGLISH LITERATURE (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer.
 543. STUDIES IN EARLY SEVENTEENTH-CENTURY LITERATURE (3-6) Major poets and prose writers from 1600 to 1660.
 544. RESTORATION LITERATURE (3) Selected studies of writers in England between 1650 and 1700.

545. CHAUCER (3-6) Critical study of the *Canterbury Tales* or *Troilus and Criseyde* and minor poems.
546. MILTON (3) The poetry and prose of John Milton.
548. ELIZABETHAN AND JACOBAN DRAMA (3-6) English drama from 1558 to 1642, exclusive of Shakespeare.
549. SHAKESPEARE (3-6) Special problems of sources, chronology, text, characterization, and motivation in the drama.
552. SWIFT AND POPE (3)
553. THE AGE OF JOHNSON (3) The work of Johnson and his circle.
554. STUDIES IN EARLY AMERICAN LITERATURE (3)
556. EIGHTEENTH-CENTURY BRITISH FICTION (3)
557. EARLY EIGHTEENTH-CENTURY BRITISH LITERATURE (3) Prose and poetry in the reign of Queen Anne, with special attention to periodical publications.
560. AMERICAN ROMANTICISM (3) The romantic movement in American literature of the mid-nineteenth century.
561. STUDIES IN THE ROMANTIC MOVEMENT (3-6)
562. STUDIES IN THE LITERATURE OF VICTORIAN ENGLAND (3-6)
564. STUDIES IN NINETEENTH-CENTURY AMERICAN LITERATURE (3) The major figures treated will vary from year to year.
573. STUDIES IN TWENTIETH-CENTURY BRITISH LITERATURE (3-6) Major writers and literary movements.
574. STUDIES IN TWENTIETH-CENTURY AMERICAN LITERATURE (3-6) Major writers and literary movements.
575. JAMES JOYCE (3-6) Alternate terms: *Ulysses* and *Finnegans Wake*. Knowledge of *Dubliners* and *A Portrait of the Artist* is assumed.
576. HEMINGWAY AND FAULKNER (3) The major works.
578. SHAW (3) The plays, prose writings, and literary influence of G.B.S.
579. T.S. ELIOT (3) Major works in poetry, criticism, and drama; pertinent scholarship and criticism.
580. ANGLO-AMERICAN APPLICATIONS OF FOLKLORE IN LITERATURE (3) A detailed examination of the nature of the folktale and its implications for literature as an oral genre. Prerequisite: a basic knowledge of folklore, as taught in Engl. 196, is assumed.
581. CONTEMPORARY LITERARY CRITICISM (3)
582. HAWTHORNE AND MELVILLE (3) Detailed study of the major works of both authors and of the relationship between the two men.
583. EMERSON AND THOREAU (3) The significant prose and poetry of the chief American transcendentalists.
584. WHITMAN AND DICKINSON (3) The major texts, with special emphasis on background and language.
586. READINGS IN LITERATURE (1-12) Programs of readings designed to meet specific needs of individual students.
587. FRANKLIN AND EDWARDS (3) Studies in the lives, works, and milieu.
588. STUDIES IN AMERICAN FICTION (3-6)
589. STUDIES IN AMERICAN POETRY (3-6)

590. COLLOQUIUM (1-3)

592. STUDIES IN AMERICAN LITERARY MYTH (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture.

593. (C.Lit. 593) ANGLO-AMERICAN FOLK SONG (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present.

595. STUDIES IN BRITISH FICTION (3-6)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

ENTOMOLOGY (ENT)

CHARLES W. PITTS, *Head of the Department*
106 Patterson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Benton, Cameron, Hower, Kim, Mumma, Pitts, Rutschky, Smilowitz, Smyth, Snetsinger, and Yendol.

Graduate Faculty: Associate Members Bode, Byers, Collison, Hull, and Jubb.

A student majoring in entomology may specialize in economic entomology, forest entomology, apiculture, insect resistance in plants, arachnology, medical or veterinary entomology, biological control, insect pathology, insect transmission of plant pathogens, ecology, morphology, embryology, taxonomy, physiology, insect behavior, or chemistry of pesticides.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one foreign language and proficiency in English.

For admission a student is required to have 24 credits in entomology and related biological sciences. Chemistry through organic, physics, mathematics through calculus, and statistics are required. A limited deficiency may be made up while pursuing graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENTOMOLOGY (ENT)

401. MEDICAL AND VETERINARY ENTOMOLOGY (3) *Kim*

409. INSECT BIOLOGY AND MANAGEMENT (3) *Rutschky*

412. FIELD ENTOMOLOGY (3) *Rutschky*

414. INSECT MORPHOLOGY AND PHYLOGENY (3) *Rutschky*

415. INSECT PHYSIOLOGY AND BIOCHEMISTRY (3) *Mumma and Smyth*

416. METHODS FOR INSECT PEST POPULATION MANAGEMENT (3) *Hower*

418. FOREST ENTOMOLOGY (3) *Cameron*

425. FRESHWATER ENTOMOLOGY (3) *Kim*

426. IMMATURE INSECTS (3)

435. ARACHNOLOGY (3) *Snetsinger*

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

515. INSECT MORPHOLOGY AND SYSTEMATICS (1-3) Current theories, controversies and advanced techniques in comparative morphology, histology, embryonic and postembryonic development, taxonomy and systematics of insects.

- 516. INSECT PHYSIOLOGY AND BIOCHEMISTRY (1-3) Selected topics in insect function and metabolism.
- 517. INSECT ECOLOGY AND BEHAVIOR (1-3) Selected aspects of the biotic and abiotic interactions of insects.
- 518. PEST MANAGEMENT (1-3) Current concepts and controversies in modern agricultural and urban pest management practice.
- 531. INSECT TOXICOLOGY (2) General principles of toxicology and survey of the actions of substances toxic to insects.
- 532. INSECT BEHAVIOR (2) Orientation reflexes, learning, communication, and social behavior; physiological bases; ecological and evolutionary implications.
- 535. BIOLOGICAL CONTROL (3) Practical and theoretical aspects of arthropod control by entomophagous insects and the place of biocontrol in integrated control programs.
- 536. INSECT PATHOLOGY (3) Diseases of arthropods and some aspects of microbial control of insects. Prerequisite: Micrb. 1.
- 542. (Biol. 542) SYSTEMATICS (3) Principles and methods of classification, phylogeny and speciation; taxonomic techniques; analysis of species, causal interpretation of animal diversity.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

ENVIRONMENTAL ENGINEERING (ENV E)

RAYMOND E. UNTRAUER, *Head of the Department of Civil Engineering*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Aron, Heinsohn, Long, McDonnell, Miller, Nesbitt, Reed, Regan, Untrauer, and Unz.

Graduate Faculty: Associate Members Chadderton and Kibler.

This program prepares students for careers in (1) facility and system design; (2) systems management; (3) environmental monitoring; (4) process development; or (5) education and research in any of the environmental areas of water quality management (potable, industrial, and wastewater), water resources, management, and air pollution control.

The entering student normally should be a graduate from an accredited program in engineering.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Entering graduate students for whom English is not the first language are required to have a score of at least 575 on the TOEFL (Test of English as a Foreign Language) examination. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of one foreign language (French, German, Russian, or Spanish) and proficiency in English. A thesis is required for the M.S. degree. An engineering report is required for the M.Eng. degree.

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in environmental engineering (course descriptions are given under Civil Engineering): C.E. 451, 452, 462, 465, 471, 472, 474, 475, 476, 551, 553, 564, 571, 572, 573, 574, 575, 577, 579, and

580. Appropriate courses offered by other departments include: Ag. 400; Ag.Ec. 442, 505; Bioch. 401, 402, 425; Biol. 410; Chem. 405; Cmp.Sc. 402; Geosc. 452; I.E. 403, 405, 509, 510; M.E. 405, 470, 506, 521, 571; Meteo. 473, 502; Micrb. 400, 417; Nuc.E. 420; Pl.Sc. 419; P.Path. 424; Pub.A. 578; R.Pl. 400, 410, 510, 520.

ENVIRONMENTAL POLLUTION CONTROL (E P C)

JOHN B. NESBITT, *In Charge of Graduate Programs in Environmental Pollution Control*
226 Merrell R. Fenske Laboratory

Degrees Conferred: M.S., M.E.P.C., M.Eng.

Graduate Faculty: Senior Members Aplan, Aron, Baker, Bartlett, Barton, Cunningham, de Maine, de Pena, Draper, Engel, Gordon, Heicklen, Heinsohn, Hunt, Kabel, Knight, Kroger, Long, Lovell, McDonnell, McKee, Nesbitt, Palmer, Panofsky, Parizek, Petersen, Reethof, Regan, Schenck, Simkovich, Sink, Stahl, Stephenson, Thomson, Unz, Witzig, and Zarkower.

Graduate Faculty: Associate Members Chadderton, Davis, DeTar, Ferguson, Goodwin, Jarrett, Kibler, Massaro, and Thuering.

This intercollege program deals with the various aspects of the control of air and water pollution and the disposal of solid wastes. Graduate instruction is under the direction of an interdisciplinary faculty committee and the departments participating in the program. The faculty consists of the committee members listed above and a larger group of graduate faculty members with a teaching and/or research interest in the area of environmental pollution control.

Students are required to pass 9 credits of core courses: C.E. 472, Water Pollution Control; C.E. 476, Solid Waste Management; and M.E. 470, Fundamentals of Air Pollution. In addition, they must select at least 21 of their total credits from a recommended course list and schedule the environmental pollution control seminars (E.P.C. 590) for three terms. If the option to prepare a thesis is selected, the research topic must be in the area of environmental pollution control and at least 6 credits of research must be taken in the department with which the student is affiliated. Students who select the nonthesis option must submit a paper. The student's adviser, the department head, and the E.P.C. program chairman determine the requirements of the paper.

Admission will be granted upon recommendation of the head of the academic department in which the student plans to complete a program and the environmental pollution control program faculty committee. Normal admission requirements include mathematics through integral calculus, plus one year of work in general physics and in chemistry. There is no foreign language requirement. Students with a 2.75 junior-senior average and with appropriate backgrounds in mathematics and science will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Entering graduate students for whom English is not the first language are required to have a score of at least 560 on the TOEFL (Test of English as a Foreign Language) examination.

ENVIRONMENTAL POLLUTION CONTROL (E P C)

590. COLLOQUIUM (1-3)

EXTENSION EDUCATION (EXTED)

DARYL K. HEASLEY, *Acting Chairman of the Committee on Extension Education*
204 Weaver Building

Degrees Conferred: M.Agr., M.Ed.

Program Committee: Heasley, Ritter, and Shellenberger.

Cooperating Faculty: Baylor, Cole, Kuhn, Lindley, Sherritt, Snetsinger, and Wuest.

This program is designed primarily to meet the needs of professionals in various extension, vocational, and adult education positions. The purpose is to educate individuals to develop attitudes, understandings, and competencies which enable them to become more effective professionals. The advisory committee will assist the student in establishing goals, planning a program of study, selecting appropriate courses, and developing a professional paper within the requirements of the degree program.

For either degree a minimum of 30 credits is required, including a professional paper. These credits should be distributed as follows: 12 credits in extension techniques, communication, and education; 3-4 credits in statistics; at least 6 credits in a minor area of interest; up to 6 credits as electives; and 3 credits for the professional paper. For the M.Ed. degree a minimum of 6 credits in education courses is required. It is suggested that 12 of the 27 credits in course work be taken at the 500 level. A maximum of 10 credits can be earned as a nonresident student.

Admission requirements include a baccalaureate degree from an accredited institution, with the student having a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Graduate Record Examinations scores (GRE scores) are required by the Graduate School.

FOOD SCIENCE (FD SC)

DAVID R. LINEBACK, *Head of the Department*
111 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Beelman, Dimick, Keeney, Kroger, Kuhn, Lineback, MacNeil, Mason, Mast, McArdle, McCarthy, Patton, Sink, Thompson, and Ziegler.

Graduate Faculty: Associate Members Forsythe, Glass, Kilara, and Molonon.

Opportunities are available for study in the fields of biochemistry and metabolism, food chemistry (carbohydrates, lipids, proteins, enzymes), microbiology, quality control, flavor control and acceptance, product evaluation, and processing. Special emphasis can be devoted to dairy, meat, plant, and poultry products, and other specific food commodities.

The requirements for the M.S. and Ph.D. programs are detailed in the Department of Food Science's publication, *Graduate Programs in Food Science*. The communication and foreign language requirement for the Ph.D. degree may be satisfied by demonstration of an intermediate knowledge of one foreign language or through completion of three courses in English language communication.

Prerequisite to graduate work is the completion of an undergraduate degree in food science, biochemistry, microbiology, or other related areas. The undergraduate program must include calculus, organic chemistry, microbiology, and general physics. Students may be admitted with deficiencies but are required to make them up without degree credit. Students who present a 3.00 junior-senior average will be considered for admission to the program, subject to the limitations of the physical facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

In addition to the courses listed below, the following courses are available in food science: A.I. 431; Ag.E. 412, 413, 414, 423, 503; A.Ntr. 401; D.Sc. 427; Hort. 528; Pty.Sc. 504.

FOOD SCIENCE (FD SC)

- 400. FOOD CHEMISTRY (3)
- 403. SANITATION AND QUALITY CONTROL (3)
- 404. SENSORY EVALUATION OF FOODS (2)
- 405. THERMAL PROCESSING (2)
- 406. WINE TECHNOLOGY AND APPRECIATION (2)
- 407. FOOD TOXINS (2)
- 408. APPLIED FOOD MICROBIOLOGY (2)
- 409. LABORATORY IN APPLIED FOOD MICROBIOLOGY (2)
- 410. CHEMICAL METHODS OF FOOD ANALYSIS (4)
- 415. MEAT SCIENCE AND TECHNOLOGY (3)
- 421. TECHNICAL CONTROL PROBLEMS (1-6)
- 490. UNDERGRADUATE SEMINAR (1)

- 505. CONCEPTS OF PRODUCT DEVELOPMENT (3) Interrelationships of processing principles and chemical and physical properties in the development of new and improved food products.
- 507. FOOD QUALITY, FOOD STANDARDS, AND CONSUMER PROTECTION (2) Problems of the food industry relating to contamination and quality of food products.
- 510. SEMINAR IN FOOD SCIENCE (1-6)
- 515. EXPERIMENTAL MEAT SCIENCE AND MUSCLE BIOLOGY (2-6) Experimental and theoretical aspects of meat science, meat product/process systems, and the quantitative biology of muscle systems used for food. Prerequisite: Fd.Sc. 400 or 415.
- 520. PROBLEMS IN FOOD SCIENCE (1-9) Special problems in dairy, horticultural, meat, poultry, and other food products.
- 521. RADIOBIOLOGY (3) Radioactivity: its nature, interaction with matter, measurement, and quantification; the use of isotopes as tracers in biological systems.
- 522. RESEARCH PROCEDURES IN FOOD SCIENCE (3) Research problems and methods in food science with major emphasis on food chemistry.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

FOREST RESOURCES (FOR R)

ROBERT S. BOND, *Director of the School of Forest Resources*
101 Ferguson Building

Degrees Conferred: Ph.D., M.S., M.Agr., M.F.R.

Graduate Faculty: Senior Members Blankenhorn, Bond, DeWalle, George, Gerhold, Hutnik, Lindzey, Myers, Shipman, Sopper, Turner, Twight, and Ward.

Graduate Faculty: Associate Members Baldwin, Johnson, Kelly, Kersavage, Lynch, McCormick, Melton, Rader, Reyburn, Steiner, Storm, Strauss, and Wakeley.

The Doctor of Philosophy and the Master of Science degree programs are oriented toward research, education, and scientific technology in the professions of forest products, forestry, and wildlife management. The foreign language requirement for the Ph.D. degree may be satisfied by demonstrating competence in one foreign language equivalent to passing three college-level courses.

The Master of Forest Resources is a professional degree which emphasizes application of knowl-

edge through managerial practices involving forest resources, industries, or the natural environments of communities and recreational areas.

The Master of Agriculture is intended to enable students to develop skills as professionals in the communication of technical knowledge. Candidates will elect a minimum of 15 credits of graduate-level courses in communication skills from courses in departments such as Agricultural Education, Instructional Media, Journalism, Recreation and Parks, Speech Communications, English, and Theatre. Any deficiencies in a student's resource specialty, as judged by his or her advisory committee, must be remedied. An acceptable paper on a selected professional problem or a report of internship training worth 3 credits or more is also required.

A thesis is required for the M.S. and Ph.D. degrees, and an original paper is required for the M.F.R. degree. Most programs of study are strengthened by including appropriate courses offered by related departments.

Faculty expertise, laboratories, and outdoor research facilities are available to support specialization in a variety of fields. Possibilities for specialization are indicated in part by the courses listed under forest products, forestry, and wildlife, and by related courses in agricultural economics, agronomy, animal nutrition, biology, business administration, chemical engineering, computer science, ecology, economics, entomology, environmental pollution control, environmental resource management, genetics, horticulture, industrial engineering, landscape architecture, meteorology, physiology, plant pathology, polymer sciences, recreation and parks, regional planning, or statistics.

For admission, an applicant should have at least a 2.75 grade-point average, a 3.00 junior-senior average, and courses that are basic to the individual's field of specialization. Ordinarily these include 12 credits in communication, 12 credits in social sciences and humanities, 12 credits in quantification including calculus and statistics, 9 credits in physical sciences, 9 credits in biological sciences, and 18 credits in forest products, forestry, wildlife, or related courses. Graduate Record Examination scores, three reference reports (forms supplied on request), and a brief statement describing the applicant's academic goals, career interests, and special qualifications are required. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to admission requirements may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

FOREST PRODUCTS (F P)

- 401. WOOD SCIENCE CONCEPTS (2)
- 402. WOOD SCIENCE PRACTICUM (1)
- 411. WOOD-ENVIRONMENTAL RELATIONSHIPS (3)
- 412. WOOD IN STRUCTURES (3)
- 413. THE CHEMISTRY OF WOOD (3)
- 414. PULP AND FIBER TECHNOLOGY (3)
- 420. PROCESSING AND MACHINING OF WOOD AND WOOD PRODUCTS (2)
- 421. GLUING AND FINISHING WOOD (2)
- 422. DRYING OF WOOD (2)
- 423. DETERIORATION AND PROTECTION OF WOOD PRODUCTS (2)
- 424. COMPOSITE WOOD PRODUCTS (2)
- 430. FOREST PRODUCTS MANUFACTURING SYSTEMS (3)
- 435. FOREST PRODUCTS PRODUCTION MANAGEMENT (3)
- 439. PULP AND TIMBER HARVESTING (3)
- 490. FOREST PRODUCTS COLLOQUIUM (1)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

502. WOOD FIBERS (3) Identification and measurement of physical and chemical characteristics of wood fibers used in paper or dissolving pulps.

511. PHYSICAL PROPERTIES OF WOOD AND FIBERS (2) Theories of accessibility, sorption, dimensional stabilization, diffusion, and permeability of cellulosic fibers and solid wood. Prerequisite: F.P. 411.

513. **WOOD CHEMISTRY (3)** Treatment of the chemical components of wood, their distribution and reactions. Prerequisite: F.P. 413.
530. **FOREST PRODUCTS INDUSTRIAL OPERATIONS ANALYSIS (2)** Research methods with emphasis on programming, simulation, and waiting line problems. Prerequisite: F.P. 435.
531. **MECHANICAL BEHAVIOR OF WOOD (3)** Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.
532. **THEORY OF ADHESION (3)** Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

FORESTRY (FOR)

403. **DENDROLOGY (3)**
416. **FOREST RECREATION (3)**
421. **SILVICULTURE (3)**
440. **FOREST ECONOMICS AND FINANCE (3)**
450. **INTRODUCTION TO OPERATIONS RESEARCH (3)**
455. **AERIAL PHOTOS IN FORESTRY (3)**
466. **FOREST RESOURCE MANAGEMENT (3)**
470. **WATERSHED MANAGEMENT (3)**
480. **POLICY AND ADMINISTRATION (3)**
496. **INDEPENDENT STUDIES (1-12)**
497. **SPECIAL TOPICS (1-6)**
508. **FOREST ECOLOGY (3)** The forest ecosystem, variations in space and time, classification, ordination techniques, dynamic aspects such as energy flow and nutrient cycling.
512. **FOREST GENETICS (3)** Qualitative and quantitative genetic principles and research methods applied in tree breeding.
517. **FOREST MICROCLIMATOLOGY (3)** A quantitative treatment of climate near the ground, with special reference to the role of forests and terrain. Prerequisite: Phys. 202.
519. **FOREST HYDROLOGY (3)** Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisite: For. 308, C.E. 51.
521. **ADVANCED SILVICULTURE (3)** Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.
525. **FOREST LAND USE (3)** Concepts of supply and demand for forest lands and their allocation to alternative uses. Prerequisites: For. 466 or Ag.Ec. 421; or Geog. 405 and 3 credits in economics.
550. **DESIGN AND ANALYSIS OF EXPERIMENTS (3)** Specialized techniques involved in the design and analysis of complex forestry research problems. Prerequisite: For. 450.
560. **TIMBER MANAGEMENT (3)** Technical methods in the organization and control of the forest property for timber production.
575. **APPLICATIONS OF FOREST ECONOMICS AND FINANCE (3)** Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 440.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**

597. SPECIAL TOPICS (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

NOTE: See also *Wildlife Management*.

FRENCH (FR)

RICHARD L. FRAUTSCHI, *Head of the Department*
316 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A.

Graduate Faculty: Senior Members Belasco, Brault, Chapman, Frautschi, Norton, and Ward.

Graduate Faculty: Associate Members Ariew, Danahy, Hale, Knight, and Makward.

This program offers training in language, literature, linguistics, and civilization. A candidate for the M.A. degree may select a program of study emphasizing language with cultural emphasis or literature. A reading knowledge of a second foreign language and written and oral comprehensive examinations are required. The candidate may submit either a thesis or a term paper. If the latter is chosen, 6 additional credits in 500-level courses must be scheduled. The M.A. degree (or equivalent) is normally a prerequisite to doctoral candidacy.

The D.Ed. degree is structured for students preparing careers emphasizing teaching, curriculum design, and administration in secondary and post-secondary education. Of the 90 required graduate credits, a minimum of 60 (including M.A. credits) must be acquired in French courses and another 15 in the College of Education. A reading knowledge of a second foreign language is also required. A thesis focusing on a pedagogical topic is selected and may be supervised by faculty in both French and education.

The Ph.D. degree prepares candidates for careers in teaching and research at the college level. A minimum of 66 credits (including M.A. credits) is required in graduate course work, 36 of which must be distributed in metropolitan literature. Candidates may specialize in French literature, linguistics, francophone literature, or, with special permission, interdisciplinary study in the humanities, social sciences, or fine arts. The communication and foreign language requirement for the Ph.D. degree may be satisfied by at least a reading knowledge of two foreign languages other than French.

The minimum requirement for admission to an advanced degree program will normally be 36 credits of post-intermediate work in language and literature. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. A brief tape recording of an original composition in French must be presented before admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

FRENCH (FR)

*1G. ELEMENTARY FRENCH FOR GRADUATE STUDENTS (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. ELEMENTARY FRENCH FOR GRADUATE STUDENTS (3) Continuation of Fr. 1G with reading practice.

500. INTRODUCTION TO OLD FRENCH (3) Analysis of the phonology, morphology, and syntax of Old French based on early literary monuments. *Brault*

503. FRENCH PHONOLOGY (3) Articulatory and acoustic correlates of distinctive features; synchronic dialectology; phonology in generative grammar. *Belasco*

504. FRENCH MORPHOLOGY AND SYNTAX (3) Principles of segmentation and decomposition; tagmemics and transformation theory; morphophonemics. *Belasco*

*No graduate credit is given for this course.

505. SEMANTIC THEORY OF THE FRENCH LANGUAGE (3) The goals of semantic description; systematic interrelation of semantic generalizations; empirical and methodological constraints. *Belasco*
510. STYLISTIQUE AVANCÉE (3) Study of rhetorical figures and expository style in prose and poetry through *dissertation* and *explication*.
511. READINGS IN OLD FRENCH (3 per term, maximum of 6) A survey of French literature to 1300, focusing in alternate terms on either the 12th or the 13th century. *Brault*
512. LATE MEDIEVAL FRENCH LITERATURE (3) The non-dramatic literary genres of the late Middle Ages, with reference to their cultural context and social function. *Knight*
516. THE SONG OF ROLAND (3) Seminar in the Old French *Chanson de Roland*, with emphasis on the problems of textual criticism and literary analysis. *Brault*
518. MEDIEVAL FRENCH DRAMA (3) The development of French drama from its liturgical origins to the flourishing comic theatre of the late Middle Ages. *Knight*
526. AGE OF RABELAIS (3) Notions of literary creativity in the context of early sixteenth-century French Humanism: readings from Rabelais, Marguerite de Navarre, Scève. *Norton*
529. SEMINAR IN RENAISSANCE LITERATURE (3 per term, maximum of 6) Intensive study of various French Renaissance writers in relation to selected artistic issues of the period. *Norton*
528. AGE OF MONTAIGNE (3) Literary culture of Renaissance France in the context of social and political crisis; readings from Montaigne, DuBellay, Ronsard, and Sponde. *Norton*
533. SEVENTEENTH-CENTURY PROSE AND POETRY (3) The development of classicism; its apogee and decline as seen in the works of major prose writers and poets. *Chapman*
534. MOLIÈRE (3) The literary achievement of Molière, the comic playwright, director, actor, and founder of the Comédie Française. *Chapman*
535. SEVENTEENTH-CENTURY FRENCH TRAGEDY (3) The development and triumph of tragedy as a literary genre with special emphasis on the achievement of Corneille and Racine. *Chapman*
540. VOLTAIRE AND HIS CONTEMPORARIES (3) The artistic and philosophical evolution of Voltaire as seen in the tragedy, the philosophical tale, and poetry. *Frautschi*
541. ROUSSEAU AND HIS CONTEMPORARIES (3) Rousseau's rationalistic critique of civilization; his sentimental rehabilitation of the individual, family, state; Rousseau, precursor of romanticism. *Frautschi*
543. SEMINAR: STUDIES IN THE ENLIGHTENMENT (3 per term, maximum of 6) Discourse and thematic analysis of selected works of French Enlightenment genres: essay, drama, fiction, poetry. *Frautschi*
561. FRENCH ROMANTICISM (3) The romantic movement in French literature with emphasis upon its major exponents in prose and poetry. *Danahy*
563. FRENCH REALISM (3) The realistic movement in French literature with emphasis upon its major exponents in prose and poetry. *Danahy*
565. SEMINAR: NINETEENTH-CENTURY STUDIES (1-6) Various nineteenth-century French writers considered in relation to selected esthetic and cultural problems raised during the period. *Danahy and Ward*
567. TWENTIETH-CENTURY FRENCH THEATRE (3) Evolution of the French theatre from the plays of the *belle époque* to the avant-garde works of today. *Makward*
569. MASTERS OF TWENTIETH-CENTURY FRENCH LITERATURE (3-6) Major literary figures of contemporary French literature. *Makward*
571. FRENCH LITERARY CRITICISM FROM SAINTE-BEUVE TO PRESENT (3) Evolution of French literary criticism from Sainte-Beuve, the "father" of modern literary criticism, to contemporary critics.
580. SEMINAR IN FRENCH LITERATURE (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor.

- 581. THEORY AND TECHNIQUES OF TEACHING FRENCH (1-6)
- 586. SYMBOLISM (3) The anti-positivistic tradition in nineteenth-century French literature dealing with the Symbolist School; its antecedents and its subsequent ramifications.
- 587. RESEARCH TECHNIQUES AND BIBLIOGRAPHY IN FRENCH LANGUAGE AND LITERATURE (1-3)
- 595. ANALYSIS OF FRENCH CIVILIZATION (3-6) French cultural aspects, other than language and literature, conducted in French with the collaboration of specialists outside the French department.
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

FUEL SCIENCE (F SC)

PHILIP L. WALKER, JR., *In Charge of Graduate Programs in Fuel Science*
101 Steidle Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Austin, Given, Palmer, Vastola, and Walker.

Graduate Faculty: Associate Members Becker and Jenkins.

This program is one of the options in which a graduate student in the Department of Materials Science and Engineering can receive an advanced degree.

Well-instrumented research facilities are available for investigation of the chemical and physical characteristics of coals, fundamentals of coal gasification and liquefaction, flame dynamics in practical combustion systems, industrial fuel efficiency, chemistry and physics of basic combustion phenomena, chemical kinetics of fast gaseous reactions, formation and removal of polluting species in combustion processes, physics and chemistry of carbonaceous solids, organic geochemistry of plant-derived sediments, modeling of energy systems, electrochemical energy conversion, and solar power generation. Students can plan a wide variety of programs of study to suit individual needs; coherent interdisciplinary programs are encouraged. The nonthesis option is available for the M.S. degree.

Competency in a foreign language is not required for the Ph.D. degree. Candidates are expected to demonstrate high proficiency in both written and spoken English.

Applications will be accepted from persons having degrees in the basic or applied physical sciences or in engineering. Students with a 2.75 junior-senior average normally will be considered for admission. Exceptions may be made for students with special abilities, interests, or backgrounds, such as extensive industrial experience in fuels or combustion.

FUEL SCIENCE (F SC)

- 421. FLAMES (3) *Palmer*
- 422. COMBUSTION ENGINEERING (3) *Reuther*
- 424. ENERGY AND FUELS IN TECHNOLOGICAL PERSPECTIVE (3) *Vastola*
- 430. AIR POLLUTANTS FROM COMBUSTION SOURCES (3) *Reuther*
- 431. THE CHEMISTRY OF FUELS (3) *Given*
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 506. CARBON REACTIONS (3) Current approaches to heterogeneous reactions in combustion and gasification of carbonaceous solids, including those derived from coal and petroleum sources. Prerequisite: Chem. 452. *Walker*

512. **HIGH-TEMPERATURE KINETICS AND FLAME PROPAGATION (3)** Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high-temperature gases. Prerequisite: F.Sc. 421. *Palmer*

520. **THERMODYNAMICS AND KINETICS OF FUEL EFFICIENCY (3)** Thermodynamic and kinetic constraints on efficiencies of thermal systems; efficiency ratios; furnace analysis; radiation in furnaces, applications and examples. Prerequisite: study of thermodynamics at the upperclass or graduate level.

522. **FLAME DYNAMICS IN COMBUSTORS (3)** Mixing and reaction in combustion chambers; combustor analysis; residence time distributions; perfectly and well-stirred combustors; models and experiments.

590. **COLLOQUIUM (1-3)**

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

NOTE: Courses in the use of X-ray diffraction, electron microscopy, spectroscopy, and electronic instrumentation in fuel science studies are listed under Materials Science.

GENETICS (GENET)

HENRY D. GERHOLD, *Chairman of the Graduate Program in Genetics*
306 Forest Resources Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Ayers, Berlin, Bullock, Buss, Cleveland, Craig, Davidson, Deering, Docherty, Fritz, Garwood, Gerhold, Ginoza, Goodwin, Grun, Hargrove, C. W. Hill, R. R. Hill, Hunt, Jacob, M. Johnson, Jones, Keith, Lang, MacCluer, MacKenzie, Marshall, R. Nelson, Person, Rapp, Risius, Rosenberg, Schengrund, Shannon, Shenk, Shiman, Snipes, Starling, J. Taylor, W. Taylor, Therrien, Todd, Vesell, Wilson, Wright, Zagon, and Zimmerman.

Graduate Faculty: Associate Members Dachtler, Dyke, Eckhardt, Ladda, Liu, Petters, Pfeifer, Schlegel, S. Smith, Steiner, Stevens, W. J. White, and Yasbin.

The intercollege program in genetics includes faculty from the colleges of Agriculture, the Liberal Arts, Medicine, and Science who serve as major advisers and committee members. Applicants are encouraged to contact any faculty member who may be a prospective major adviser. Assistantship or fellowship applications should be submitted by January. Courses may be taken at either University Park or the Hershey Medical Center.

Opportunities for graduate study and research are available in biochemical, developmental, human, microbiological, viral, molecular, and population genetics; cytogenetics; pharmacogenetics; and breeding of plants or animals. Organisms available for research include fungi, bacteria, viruses, fish, rodents, birds, domestic animals, humans, forest trees, and grain, forage, and horticultural plants. The committee appointed for each student, with the approval of the program chairman, has the responsibility for determining course work, specific requirements in communication skills exceeding the minimum, and research acceptable for satisfying degree requirements. The requirement in communication and foreign language skills for the Ph.D. degree may be satisfied by fulfilling the requirement of the thesis adviser's department or program.

Students with a grade-point average of 3.00 or better and with appropriate course backgrounds in biology, science, and communications courses will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Students with limited deficiencies may be admitted, but they must make up such deficiencies concurrently with their graduate studies.

The following genetics courses are available: Agro. 411, 509, 510, 511; An.Sc. 422, 455; Anthy. 400, 500; Bioch. 514; Biol. 422, 426, 427, 428, 429, 465, 533; B.Chem. 503; Bphys. 430, 589; C.Med. 503; For. 512; Hort. 407, 444, 514; Micrb. 516; Micro. 553, 556; Ped. 525, 526; Pharm. 515,

540; P.Path. 543. Twelve credits in these courses, including at least 3 credits in acceptable statistics courses, and 3 credits per year in genetics seminar (Genet. 590 or Pharm. 515) are required for the M.S. degree in genetics or a minor in genetics for a Ph.D.; 15 credits in these courses and 3 credits per year in genetics seminar are required for a Ph.D. major in genetics. Transfer credits for certain courses in genetics may be accepted as substitutes for the above-listed courses.

GEOGRAPHY (GEOG)

RONALD ABLER, *Head of the Department*
302 Walker Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Abler, Downs, Erickson, Gould, Knight, Lewis, Miller, Rodgers, Simkins, Wernstedt, Williams, Yapa, and Zelinsky.

Graduate Faculty: Associate Member Goodwin.

The student may concentrate in subjects that call upon the special skills and interests of the staff. At the present time these include the American landscape, behavioral geography, communication systems, cultural geography of Anglo-America, cultural geography of Southeast Asia, environmental pollution control, geographic analysis, geography of the developing world, geographic theory, human geography of the U.S.S.R., human use of environment, industrial location, macrospatial analysis in regional and urban development, population problems, and regional economic development. All students receive training in cartographic and statistical techniques.

For the M.S. degree, the student has the option of completing a thesis or two papers. The master's program is broadly based, designed to provide a beginning graduate student with basic training in systematic fields, as well as in geographic theory and research techniques. This basic training underlies more specialized study at the doctoral level, where a candidate selects two fields of concentration. A student may elect to specialize in the geography of a region only if faculty members have research experience in that region. The communication and foreign language requirement for the Ph.D. degree shall be satisfied in a manner approved by the candidate's doctoral committee.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

Qualified students also may select population issues as an optional area of specialization. In addition to departmental admission requirements, the Population Issues Committee evaluates the student's interest and aptitude for the training program, which consists of a minimum of 21 credits of interdisciplinary course work in population.

GEOGRAPHY (GEOG)

401. HISTORICAL GEOGRAPHY OF NORTH AMERICA (3) *Lewis or Zelinsky*
402. CULTURAL AND ANTHROPOGEOGRAPHY (3) *Zelinsky*
405. GEOGRAPHY OF POPULATION (3) *Simkins or Zelinsky*
406. HUMAN USE OF ENVIRONMENT (3) *Goodwin or Knight*
410. CARTOGRAPHY — MAP DESIGN AND CONSTRUCTION (3) *Abler*
411. ADVANCED CARTOGRAPHY (3) *Abler*
412. THE GEOGRAPHY OF THE FUTURE (3) *Abler*
413. BEHAVIORAL APPROACHES TO GEOGRAPHY (3) *Downs*
416. LOW-ENERGY LIVING (3) *Goodwin*
420. URBAN GEOGRAPHY (3) *Erickson*
427. GEOGRAPHY OF THE SOVIET UNION (3) *Rodgers*
433. REGIONAL CLIMATOLOGY (3) *Wernstedt*

434. REGIONAL PHYSIOGRAPHY (3) *Lewis*
 440. GEOGRAPHY OF MIDDLE AMERICA (3) *Simkins*
 441. GEOGRAPHY OF SOUTH AMERICA (3) *Simkins*
 442. REGIONAL SYSTEMS IN EUROPE (3) *Miller*
 443. GEOGRAPHY OF THE ORIENT (3) *Wernstedt*
 444. GEOGRAPHY OF AFRICA (3) *Knight*
 445. GEOGRAPHY OF SOUTHERN ASIA (3) *Wernstedt*
 450. DEVELOPMENT OF GEOGRAPHIC THOUGHT (3) *Abler*
 451. MAP INTERPRETATION (3) *Lewis*
 452. INTERPRETATION OF AERIAL PHOTOGRAPHS (3) *Goodwin*
 454. SPATIAL ANALYSIS I (3) *Gould or Williams or Yapa*
 455. SPATIAL ANALYSIS II (3) *Gould or Williams or Yapa*
 457. GEOGRAPHIC DATA SYSTEMS (4) *Williams*
 460. POLITICAL GEOGRAPHY (3) *Lewis or Williams*
 470. INDUSTRIAL LOCATION AND DEVELOPMENT (3) *Rodgers*
 475. GEOGRAPHY OF COMMUNICATIONS SYSTEMS (3) *Abler*
 495. DIRECTED READINGS (1-9)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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500. INTRODUCTION TO GEOGRAPHIC RESEARCH (3)
 502. REGIONAL THEORY (3) Taxonomic methods of uniform-functional regionalization; canonical linkages; intraregional relationships; Wilson models of macrocanonical ensembles.
 503. ADVANCED REGIONAL GEOGRAPHY (3-12) Intensive study at an advanced level of selected regions or sections of the continents. Prerequisite: 12 credits in geography.
 504. PHYSICAL GEOGRAPHY SEMINAR (3-12) The examination of current problems and theories in physical geography through critical discussion of the literature and student research.
 505. ECONOMIC GEOGRAPHY SEMINAR (3-12) The examination of current problems and theories in economic geography through critical discussion of the literature and original student research.
 508. CULTURAL GEOGRAPHY SEMINAR (3-6) The exploration of current problems and theory in cultural geography through critical discussion of the literature and original student research.
 509. POPULATION GEOGRAPHY SEMINAR (3) Selected problems in population geography with emphasis on analysis and presentation of data. Prerequisite: Geog. 405.
 510. ANALYTIC CARTOGRAPHY (3) Computer graphics, geographical matrix operations, response functions, sampling resolution, quantization, map generalization, pattern recognition, generalized spatial partitionings, and map projections. Prerequisites: Geog. 454, 455.
 517. GEOGRAPHIC MODELING (1) Spatial modeling, mapping, and transformations of elementary geographic problems.
 520. METROPOLITAN ANALYSIS (3) Land use models, urban factorial ecology; intraurban movements; urban renewal, ghetto structure, residential change; commercial structure, blight. Prerequisite: Geog. 420 or 454.
 590. COLLOQUIUM (1-3)
 596. INDIVIDUAL STUDIES (1-6)
 597. SPECIAL TOPICS (1-6)

GEOSCIENCES

C. WAYNE BURNHAM, *Head of the Department*
204 Deike Building

There are three graduate degree programs to which a student can be admitted: geochemistry and mineralogy, geology, and geophysics. Transfer from one of these majors to another is possible, provided the basic admission requirements of the program into which the student is transferring are met.

For admission applicants are required to submit the results of the Graduate Record Examination and are generally expected to have a bachelor's degree in some branch of the natural or physical sciences, engineering, or mathematics. An applicant also is expected to have completed standard introductory courses in geosciences, chemistry, physics, and mathematics through integral calculus, plus 15 credits of intermediate-level work in one or a combination of these subjects. Greater than minimal preparation within these limits may be required in chemistry and mineralogy for the geochemistry and mineralogy major; in geology and biology for the geology major; and in mathematics and physics for the geophysics major. Applicants who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies. Students with special backgrounds, abilities, and interests whose undergraduate grade-point average in courses pertinent to geosciences is below a 3.00 will be considered for admission only when there are strong indications that a 3.00 average can be maintained at the graduate level. The foreign language requirement for the Ph.D. degree may be satisfied by elementary competence in two languages other than English or by comprehensive competence in one. The student has the option of a thesis or a paper for the M.S. degree.

GEOSCIENCES (GEOSC)

- 402. (Meteo. 446) NATURAL DISASTERS SEMINAR (2)
- 403. GEOLOGICAL ASPECTS OF ENVIRONMENTAL PROBLEMS (3) *Dachille*
- 404. GEOLOGY OF THE SOLAR SYSTEM (3)
- 408. (Mat.Sc. 408) X-RAY DIFFRACTION (3) *Dachille*
- 409. OPTICAL MINERALOGY (3) *Kerrick*
- 411. (Mat.Sc. 411) INSTRUMENTAL TECHNIQUES APPLIED TO MATERIALS AND MINERAL SCIENCES PROBLEMS (1-6)
 - Unit A. X-RAY DIFFRACTION
 - Unit B. TRANSMISSION ELECTRON MICROSCOPY
 - Unit C. SPECTROSCOPY
 - Unit D. ELECTRON MICROPROBE ANALYSIS
 - Unit E. SCANNING ELECTRON MICROSCOPY
 - Unit F. ABSORPTION SPECTROSCOPY
- 415. GEOCHEMISTRY (3)
- 416. STABLE AND RADIOACTIVE ISOTOPES IN GEOSCIENCES: INTRODUCTION (3) *Dachille and Deines*
- 419. INTRODUCTION TO ORGANIC GEOCHEMISTRY (3) *Given*
- 420. (Biol. 420) PALEOBOTANY (3) *Spackman*
- 421. INTRODUCTION TO COAL PETROLOGY (3) *Davis*
- 422. COAL MEASURE GEOLOGY (3) *Davis*
- 423. (Biol. 423) INTRODUCTORY PALYNOLOGY (3) *Traverse*
- 425. FOSSILS (3) *Guber*
- 426. PALEOECOLOGY (3) *Cuffey*
- 427. (Biol. 427) EVOLUTION (3) *Cuffey and Traverse*
- 430. PETROLOGY (5)
- 431. PETROGRAPHY (3)
- 432. PETROLOGY (3) *Kerrick and Thornton*
- 434. VOLCANOLOGY (3) *Thornton*
- 436. PETROLOGY AND GEOCHEMISTRY OF SEDIMENTS (3) *Williams*
- 438. BIOGENIC SEDIMENTATION (3)

- *439. STRATIGRAPHY (3) *Cuffey and Williams*
- 440. MARINE GEOLOGY (3) *Schmalz*
- 442. EVOLUTION OF COASTLINES (3) *Slingerland*
- 445. COASTAL GEOLOGY (4) *Guber, Schmalz, Slingerland, and Williams.*
- 451. ECONOMIC GEOLOGY (3) *Gold and Rose*
- 452. INTRODUCTION TO HYDROGEOLOGY (3) *Parizek*
- 454. GEOLOGY OF OIL AND GAS (3) *Scholten*
- 457. GEOCHEMICAL EXPLORATION (3) *Rose*
- 461. GEOLOGY OF NORTH AMERICA (3) *Wright*
- *462. PRINCIPLES OF GEOMORPHOLOGY (3-6) *Potter*
- 465. STRUCTURAL GEOLOGY (3) *Gold*
- 466. MECHANICS OF GEOLOGICAL MATERIALS (3) *Voight*
- *470. INTRODUCTION TO FIELD GEOLOGY (3) *Gold and Wright*
- *471. FIELD STUDIES IN NORTH AMERICA (3).
- 472. FIELD GEOLOGY (7-8)
- 473. TOPOGRAPHIC MAPS AND AERIAL PHOTOGRAPHS (1)
- 480. PHYSICS OF THE EARTH (3) *Graham*
- 482. GEOPHYSICAL WELL LOGGING (3) *Lavin*
- 484. GEOPHYSICAL SURVEYING (3)
- 487. ANALYSIS OF TIME SERIES (3) *Lavin*
- 488. POTENTIAL THEORY APPLIED TO EARTH PROBLEMS (3) *Alexander*
- 490. GEOLOGICAL SCIENCES SEMINAR (1-6 per term)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

GEOLOGICAL SCIENCES (G SC)

- 547. EVOLUTION IN ECOSYSTEMS (3) Evolutionary attributes of ecosystems; manifestation of evolutionary mechanisms in ecological systems; evolution of interspecies integrations; evolution of selected ecosystems.
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

GEOCHEMISTRY AND MINERALOGY (G M)

DERRILL M. KERRICK, *In Charge of Graduate Programs in Geochemistry and Mineralogy*
204 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barnes, Burnham, Dachtel, Deines, Kerrick, Muan, Ohmoto, Rose, Roy, Smith, Thornton, and White.

Graduate Faculty: Associate Members Blencoe, Cathles, Eggler, Lasaga, and Suhr.

Areas of specialization include phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical exploration, cosmochemistry, high-temperature and high-pressure geochemistry, ore-forming processes, igneous, sedimentary, and metamorphic petrology, experimental petrology and mineralogy, crystallography, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

GEOCHEMISTRY AND MINERALOGY (G M)

- 502. (Geol. 502) CARBONATES IN THE MARINE ENVIRONMENT (3) Ancient carbonate rocks and re-

*This course includes from one to several field trips for which an additional charge will be made.

cent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach.

503. (Mat.Sc. 503) KINETICS OF MATERIALS PROCESSES (3) Introduction to application of transition state theory and mass transfer to the kinetics of materials and mineral processes. Prerequisites: Math. 100, Chem. 451; G.M. 521 or Mat.Sc. 501. *Lasaga*

510. METAMORPHIC PETROLOGY (2-4 per term, maximum of 6) Analysis of theoretical, experimental, and field aspects of metamorphic reactions. Prerequisites: G.M. 520, 521, and Geosc. 432. *Kerrick*

512. (Mat.Sc. 512) PRINCIPLES OF CRYSTAL CHEMISTRY (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions. *Roy*

*513. SCIENTIFIC METHOD IN GEOSCIENCE (3) Problem formulation, sampling designs, selection of variates, and comparison of techniques for analysis of aggregates.

*514. STATISTICAL AND ELECTRONIC DATA-PROCESSING PROCEDURES FOR GEOSCIENCE (3) Statistical analysis of experimental data using univariate and bivariate procedures.

*515. ORE MICROSCOPY (3) Optical and hardness measurements and phase equilibria as used in identification and interpretation of textures of ore minerals. *Barnes*

*517. AGE DETERMINATIONS (1-2) Geochemistry of radioactive elements and their daughters; age determination techniques and observations. *Deines*

518. STABLE ISOTOPE GEOCHEMISTRY (3) Theory of isotope fractionation mechanisms; its application to a wide range of problems in the earth and planetary sciences. *Deines*

519. PHASE EQUILIBRIA IN MINERAL SYSTEMS AT HIGH TEMPERATURES (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams. *Muan*

520. P-T-X PHASE EQUILIBRIA (3) Phase equilibrium in mineral systems with pressure as a variable. *Eggler*

521. MINERAL EQUILIBRIA (3) A thermodynamic treatment of minerals and their reactions under geochemically important conditions of temperature and pressure. Prerequisite: Chem. 451. *Muan and Lasaga*

522. GEOCHEMISTRY OF AQUEOUS SYSTEMS (2-3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, PO_2 -pH relations applied to ground water, sea water, hydrothermal fluids. Prerequisites: Chem. 451-452; Geosc. 432, 436. *Barnes and Schmalz*

*523. WATER-RESOURCE GEOCHEMISTRY (2-4) Topics and problems concerning the chemical quality of surface waters and ground waters related to hydrogeologic and cultural controls.

*524. (Mat.Sc. 524) VIBRATIONAL SPECTRA OF MATERIALS AND MINERALS (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization and glass research. Prerequisites: Phys. 412, 471. *White*

*525. ELECTRON PROPERTIES OF MINERALS (2) Application of spectroscopy to mineralogy, crystal field, EPR, NMR, Mossbauer spectra. Application to order-disorder, element distribution, mineral stability. Prerequisites: Phys. 412, 471. *White*

526. PROBLEM SOLVING IN GEOSCIENCE (3) Multivariate statistical analysis, decision making, operations research, and systems analysis in geoscience.

*527. MINERALOGY I — SILICATES (3) Detailed study of the crystal structures and crystal chemistry of the silicate minerals. *Smith*

*528. MINERALOGY II — NONSILICATES (3) Detailed study of the crystal structures and crystal chemistry of the nonsilicate minerals. *Smith*

*Offered alternate years.

- *531. (Mat.Sc. 531) TRANSMISSION ELECTRON MICROSCOPY (2) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences. Prerequisite: Min. 411B (Mat.Sc. 411B). *Thrower*
- *532. (Mat.Sc. 532) STRUCTURE ANALYSIS (2) Crystal structure determination methods; space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Geosc. 408 (Mat.Sc. 408). *Smith*
- *533. (Mat.Sc. 533) SINGLE CRYSTAL METHODS (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Geosc. 408 (Mat.Sc. 408). *Ryba*
- *534. (Mat.Sc. 534) DIFFRACTION BY CRYSTALS (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescence, polarization. Prerequisite: Geosc. 408 (Mat.Sc. 408). *McKinstry*
- *535. (Mat.Sc. 535) GEOMETRICAL CRYSTALLOGRAPHY (3) Derivation of lattices, types, point groups, and space groups, with applications. *Smith*
- *538. (Mat.Sc. 538) ELECTRON BEAM ANALYSIS OF SOLIDS VIA X-RAY AND ELECTRON EMISSION (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids.
540. METEORITICS (2) Mineralogy, petrology, and chemistry of meteorites; theories of their origin and formation. Prerequisite: Geosc. 432.
542. ELEMENT DISTRIBUTION IN THE EARTH (3) Principles and data from studies of phase equilibria, petrology and crystal structure as related to distribution of elements in minerals, rocks, and the earth.
550. IGNEOUS PETROLOGY (2-3) Magmatic processes and their expression in the mineralogy, major and trace element chemistry, and isotopic composition of igneous rocks. Prerequisite: Geosc. 432. *Thornton*
551. PETROGENESIS (2-3) Application of theory and experimental results to the origin of igneous rocks. Prerequisites: G.M. 520, 521. *Burnham*
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

GEOLOGY (GEOL)

DAVID P. GOLD, *In Charge of Graduate Programs in Geology*
310 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Cuffey, Davis, Gold, Guber, Parizek, Schmalz, Scholten, Spackman, Traverse, Voight, Williams, and Wright.

Graduate Faculty: Associate Member Slingerland.

Programs are offered in stratigraphy, paleontology, sedimentation, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, engineering geology, marine geology and chemical oceanography, coal geology, coal petrology, and geology of metallic and nonmetallic deposits.

*Offered alternate years.

GEOLOGY (GEOL)

502. (G.M. 502) CARBONATES IN THE MARINE ENVIRONMENT (3) Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach.
503. PALEONTOLOGY (3-6 per term, maximum of 9) Morphology of animal groups significant for their fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology. *Cuffey*
504. HISTORY AND FOUNDATIONS OF GEOLOGY (2-4) Theoretical aspects of geology: spatio-temporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought. *Williams*
506. SEDIMENTS OF THE WORLD (2-3 per term, maximum of 6) Evolution of sediments from Archean to recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity. Prerequisites: Min. 512, 514. *Scholten and Williams*
509. (Mn.Ec. 509) GEOLOGY AND ECONOMICS OF THE CONSTRUCTION MATERIALS (3) Occurrence, origin, and marketing of the mineral materials used by the construction industry. Economic and geologic evaluation of actual deposits. *Schenck and Wright*
510. (Mn.Ec. 510) GEOLOGY AND ECONOMICS OF THE INDUSTRIAL MINERALS (3) Occurrence, origin, and marketing of the industrial minerals and evaluation of deposits. Chemical and ceramic raw materials emphasized. *Schenck and Wright*
511. ORE DEPOSITS: PRINCIPLES (3-6) Geological and geochemical processes controlling ore deposition; genetic classification of ore deposits. Prerequisite: Geosc. 451. *Staff*
512. ORE DEPOSITS: TYPES (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511. *Staff*
524. COAL PETROLOGY (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Davis*
526. (Biol. 526) PROBLEMS IN PALYNOLOGY (1-6) Systematics: paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history. *Traverse*
545. GLACIAL GEOLOGY (3) Glaciers: their characteristics, causes, deposits, landforms, effects in periglacial regions. *Parizek*
546. PRINCIPLES OF PHOTOGEOLOGY (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: Geosc. 462, 465. *Gold*
551. DYNAMIC STRUCTURAL GEOLOGY AND GEOTECTONICS (3-6) Phenomena of fracturing, faulting, folding; stress and (finite) strain analysis, physical and analytical models; deformational environments; tectogenesis and orogenesis. *Scholten, Voight, and Wright*
555. ADVANCED STRUCTURE AND PETROFABRICS (1-3) Macroscopic and mesoscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks. *Gold*
562. FLUVIAL GEOMORPHOLOGY (3) Process-oriented analysis of the variables of the fluvial system, emphasizing man's interaction.
571. GEOLOGY FIELD TRIP (1 per year) Field study of regional geologic features with trips in successive years to differing geologic provinces. *Slingerland*
581. HABITAT OF OIL (3) Geologic setting of petroleum as determined by basin tectonism, sedimentation, hydraulic and capillary forces, and reservoir textures. *Scholten*
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

GEOPHYSICS (GPHYS)

SHELTON S. ALEXANDER, *In Charge of Graduate Programs in Geophysics*
403 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Alexander, Graham, Greenfield, Howell, and Lavin.

Graduate Faculty: Associate Members Langston and Martin

Students may specialize in seismology, physical properties of rocks, geophysical surveying, geomagnetism, paleomagnetism, geoelectricity, gravity, wave propagation, time-series analysis, space applications of geophysics, tectonics, earth physics, and planetary sciences.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, and earth sciences; and at least 16 credits of intermediate-level work in any one or a combination of these subjects. Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field.

GEOPHYSICS (GPHYS)

502. SEISMIC INSTRUMENTS (3) Characteristics and design of seismometers and seismic recorders.

504. COMMUNICATION THEORY FOR GEOPHYSICISTS (3) Basic theory of random processes leading to, and including, optimum filters; geophysical applications to gravity and seismic data analysis.

506. MATERIAL PROPERTIES AND THE CONSTITUTION OF EARTH (3) Application of the properties of materials to the composition and physical state of earth's crust, mantle, and core.

507. SEISMOLOGY (3 per unit)

Unit A. Basic theory; seismic methods for inferring structure of planetary interiors; observational techniques; seismic event location, magnitude, and damage potential.

Unit B. Advanced wave propagation theory; mathematical representation of seismic sources; inversion theory; computational methods.

508. TECTONICS (3) Seminar in the cause and nature of the principal deformations of the earth.

512. GRAVITY AND MAGNETICS (2) Advanced applied methods; application of filter theory and wavenumber domain analysis to data enhancement and interpretation. Prerequisite: Geosc. 487.

513. ELECTRICAL AND ELECTROMAGNETIC METHODS (2) Advanced applied techniques; theory and procedures for determining subsurface electrical conductivity.

514. SEISMIC METHODS (2) Advanced applied seismic techniques; application of linear system analysis to seismic reflection interpretation problems. Prerequisite: Geosc. 487.

515. ADVANCES IN EXPLORATION GEOPHYSICS (2) Special topics and new developments in exploration geophysics.

517. COMPUTATIONAL METHODS IN GEOPHYSICS (3) Practical methods of modeling geophysical phenomena for geologic structures; data analysis techniques; systematic inversion of geophysical data; special mathematical approximations.

521. THERMAL STATE OF THE EARTH (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

NOTE: See the *Geosciences (Geosc.)* listing for 400-level Geophysics courses. Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Mineralogy.

GERMAN (GER)

ERNST SCHÜRER, *Head of the Department*
S-323 Burrowes Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Senior Members Ebbinghaus, Kopp, Preisner, and Schürer.

Graduate Faculty: Associate Members Browning, Keune, and Ziegler.

There is opportunity for major emphasis upon literature, philology, or the teaching of German. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages.

Students may qualify for the M.A. and M.Ed. degrees either by writing a thesis — which is recommended if a student wishes to be considered for Ph.D. candidacy — or by submitting an essay to the department and taking additional 500-level German courses in lieu of 6 credits of thesis research.

Minimum qualifications for admission include 30 undergraduate credits in German beyond the intermediate level; provision is made, however, for admission with limited deficiencies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

GERMAN (GER)

- 401. ADVANCED COMPOSITION (3)
- 411. THE TEACHING OF GERMAN (3)
- 412. STRUCTURAL ANALYSIS OF MODERN GERMAN (3)
- 430. HISTORY OF THE GERMAN LANGUAGE (3)
- 440. GERMAN STUDIES (3)
- 443. (C.Lit. 443) LITERARY RELATIONS OF GERMANY WITH ENGLAND AND AMERICA (3-9)
- 445. THE VIKINGS (3)
- 450. MEDIEVAL GERMAN LITERATURE I (3)
- 451. MEDIEVAL GERMAN LITERATURE II (3)
- 452. LITERATURE OF THE RENAISSANCE (3)
- 460. LITERATURE OF THE BAROQUE (3)
- 461. LITERATURE OF THE ENLIGHTENMENT (3)
- 462. LITERATURE OF THE LATE EIGHTEENTH CENTURY (3)
- 470. GOETHE (3)
- 471. SCHILLER (3)
- 472. ROMANTICISM (3)
- 480. REALISM (3)
- 481. EARLY TWENTIETH CENTURY (3)
- 482. RECENT GERMAN LITERATURE (3)
- 496. INDEPENDENT STUDIES (1-12)

*1G. ELEMENTARY GERMAN FOR GRADUATE STUDENTS (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary German for Graduate Students (3) Continuation of Ger. 1G with opportunity for reading in special fields.

500. BIBLIOGRAPHY AND RESEARCH TECHNIQUES (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language.

*No graduate credit is given for this course.

520. INTRODUCTION TO MIDDLE HIGH GERMAN (3) Descriptive and historical grammar; readings in simple Middle High German texts.
521. READINGS IN MIDDLE HIGH GERMAN (3) Intensive reading in Middle High German literature, especially of the *Blütezeit*. Prerequisite: Ger. 520.
522. OLD HIGH GERMAN (3) Essentials of the grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D.
523. GOTHIC (3) Introduction to the historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English.
525. OLD ICELANDIC (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.
531. SEMINAR IN MEDIEVAL GERMAN LANGUAGES AND LITERATURES (3-6)
541. SEMINAR IN THE LITERATURE OF THE REFORMATION AND BAROQUE (3-6)
551. SEMINAR IN THE LITERATURE OF THE ENLIGHTENMENT AND THE AGE OF GOETHE AND SCHILLER (3-6)
561. SEMINAR IN POST-IDEALISTIC LITERATURE (3-6)
571. SEMINAR IN MODERN GERMAN LITERATURE (3-6)
581. SEMINAR IN LITERARY GENRES (3-12) Special studies in the German lyric, drama, short story, and novel.
591. SEMINAR IN GERMAN LITERARY CRITICISM (3)
595. INDEPENDENT STUDY (1-9) Selected projects in the study of German literature and philology. Prerequisite: Ger. 500.
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

HIGHER EDUCATION (HI ED)

JOHN HARDIN BEST, *In Charge of Graduate Programs in Higher Education*
319 Rackley Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Eddy, Flexner, Godbey, Ikenberry, Lindsay, Martorana, Mortimer, Sweitzer, and Toombs.

Graduate Faculty: Associate Members Moore and Tierney.

The graduate program in the higher education major has as its goal the preparation of individuals who will pursue careers as administrators, faculty, or researchers in the nation's colleges and universities and in a variety of public and private agencies and associations. With emphasis on the systematic study of higher education, the program builds on the scholarly and scientific disciplines offered throughout the University and applies these studies to the professional functions and responsibilities which its graduates will assume.

With mounting awareness of the need for educational reforms and for improved teaching, other departments throughout the University encourage their graduate students to pursue a minor in higher education. The higher education faculty cooperates in this program — which is administered through the students' major departments — by offering a number of courses and seminars designed to promote understanding of post-secondary teaching.

The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Those with a junior-senior average of 3.00, a graduate average of 3.50, and a standardized test score comparable to a 60 on the Miller Analogies Test (MAT) are usually admitted to the D.Ed.

program. Applicants with a junior-senior average of 2.70, a graduate average of 3.20, and a MAT score of 50, and with special backgrounds, abilities, and interests will be considered for admission. Some outstanding students may be admitted to the doctoral program with only the baccalaureate degree, but they will earn the master's degree *en route*. For information about special requirements in the higher education major, write: Higher Education, The Pennsylvania State University, 319 Rackley Building, University Park, PA 16802.

HIGHER EDUCATION (HI ED)

460. (Ed.Adm. 460) INTRODUCTION TO ADULT EDUCATION (3)

545. HIGHER EDUCATION IN THE UNITED STATES (2-3) A basis for all courses in higher education. Current issues are analyzed and trends of the future anticipated.

546. COLLEGE TEACHING (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

547. INTERNSHIP IN HIGHER EDUCATION (1-9) Supervised experience in administrative offices, in research, on instructional teams, and in college teaching.

548. CURRICULUMS IN HIGHER EDUCATION (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. COMMUNITY JUNIOR COLLEGE AND THE TECHNICAL INSTITUTE (2-3) Distinctive contributions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration, and finance.

550. THE PROFESSIONS AND THE EDUCATION OF TEACHERS (3) The nature of a profession and dimensions of professional education in the United States are explored. Trends and issues examined.

552. ADMINISTRATION IN HIGHER EDUCATION (2-3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

554. THE HISTORY OF AMERICAN HIGHER EDUCATION (3) An examination of the development of American higher education against the background of influential social, political, economic, and intellectual issues.

556. COLLEGE STUDENTS (3) Characteristics of college students; changes during college years; educational challenges and responses. Prerequisites: Hi.Ed. 545 or Psy. 426 or I.F.S. 435.

575. (Ed.Adm. 575) ADMINISTRATION OF ADULT EDUCATION (3) The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

HISTORY (HIST)

KENT FORSTER, *Head of the Department*
601 Liberal Arts Tower

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Ameringer, Borza, Brown, Duiker, Eggert, Enteen, Forster, Frantz, Hassler, Maddox, Murray, Silverman, Sun, and Utechin.

Graduate Faculty: Associate Members Garner, Goldschmidt, Green, Griffith, Harvey, Knight, Linker, Meier, Spielvogel, Stebbins, and Sweeney.

Graduate work is offered in the following areas of history: ancient, medieval, Europe since 1500, Great Britain and the British Empire, Russia and Eastern Europe, the Middle East, the Far East, the United States, and Latin America. These areas are subdivided into chronological, national, and topical fields.

The candidate for the M.A. or M.Ed. degree selects one of the above areas for the master's examination. Some courses are required in an area in history other than the examination area and in a cognate field or archival option. (The cognate field for an M.Ed. candidate must be in education.) With the consent of the adviser, a master's candidate may substitute additional course work and a paper for a thesis.

The candidate for the doctor's degree must pass examinations in one of the above areas, in a thesis field within that same area, and in one field from a second area. The student must also pass an examination in a single cognate field, or in a study area made up of a number of academic disciplines related to the subject of the thesis. The communication and foreign language requirement for the Ph.D. may be satisfied by a reading knowledge of two foreign languages or one language and work in quantitative techniques. No foreign language is required for the D.Ed. degree, but the candidate must complete a minor in education.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of America from its discovery to the present. Students with a 3.00 junior-senior average and better than a 3.00 average in all undergraduate history courses and appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Each applicant must provide Graduate Record Examination scores and at least three letters of recommendation.

HISTORY (HIST)

401. CLASSICAL CIVILIZATION (3) *Borza and Harvey*
402. THE RISE OF THE GREEK POLIS (3) *Borza*
403. ALEXANDER THE GREAT AND THE HELLENISTIC WORLD (3) *Borza*
404. THE ROMAN REPUBLIC (3) *Harvey*
405. THE PAX ROMANA (3) *Harvey*
406. THE LATER ROMAN EMPIRE (3) *Harvey*
407. THE MIDDLE AGES FROM CONSTANTINE TO THE CRUSADES (3) *Sweeney*
408. THE MIDDLE AGES FROM THE CRUSADES TO THE RENAISSANCE (3) *Sweeney*
410. BYZANTINE CIVILIZATION (3)
411. HISTORY OF ENGLAND IN THE MIDDLE AGES (3) *Sweeney*
412. INTELLECTUAL HISTORY OF THE MIDDLE AGES (3) *Sweeney*
414. THE RENAISSANCE (3) *Spielvogel*
415. THE REFORMATION (3) *Spielvogel*
417. THE AGE OF ABSOLUTISM (3) *Green*
418. THE FRENCH REVOLUTION AND THE NAPOLEONIC ERA (3) *Green*
419. NINETEENTH-CENTURY EUROPE (3) *Rosenblatt*
420. RECENT EUROPEAN HISTORY (3) *Forster*
421. INTELLECTUAL AND CULTURAL HISTORY OF EUROPE, 1600-1800 (3) *Knight*
422. INTELLECTUAL AND CULTURAL HISTORY OF EUROPE SINCE 1800 (3) *Knight and Silverman*
423. SOCIAL AND ECONOMIC HISTORY OF EUROPE SINCE 1750 (3) *Silverman*
425. DIPLOMATIC HISTORY OF EUROPE SINCE 1870 (3) *Forster*
427. GERMANY SINCE 1640 (3) *Silverman*
428. FRANCE SINCE 1610 (3) *Knight*
430. EASTERN EUROPE IN MODERN TIMES (3) *Enteen*
432. HISTORY OF RUSSIA TO 1700 (3) *Utechin*
433. IMPERIAL RUSSIA, 1700-1917 (3) *Utechin*
434. HISTORY OF THE SOVIET UNION (3) *Enteen*
436. BRITAIN UNDER THE TUDORS AND STUARTS, 1485-1688 (3) *Linker*
437. GREAT BRITAIN, 1688-1832 (3) *Linker*
438. GREAT BRITAIN SINCE 1832 (3) *Linker*
440. COLONIAL AMERICA TO 1753 (3) *Frantz*

441. REVOLUTIONARY AMERICA, 1753-1783 (3) *Frantz*
442. THE FORMATIVE PERIOD OF AMERICAN HISTORY (3) *Brown*
443. THE MIDDLE PERIOD OF AMERICAN HISTORY (3) *Brown*
444. THE UNITED STATES IN CIVIL WAR AND RECONSTRUCTION (3) *Hassler*
445. THE EMERGENCE OF MODERN AMERICA (3) *Eggert*
446. AMERICA BETWEEN THE WARS (3) *Murray*
447. RECENT AMERICAN HISTORY (3) *Murray*
449. CONSTITUTIONAL HISTORY OF THE UNITED STATES TO 1877 (3) *Stebbins*
450. CONSTITUTIONAL HISTORY OF THE UNITED STATES SINCE 1877 (3) *Stebbins*
451. HISTORY OF AMERICAN POLITICAL PARTIES (3)
452. DIPLOMATIC HISTORY OF THE UNITED STATES TO 1900 (3) *Maddox*
453. THE DIPLOMATIC HISTORY OF THE UNITED STATES SINCE 1900 (3) *Maddox*
454. AMERICAN MILITARY HISTORY (3) *Hassler*
455. AMERICAN ECONOMIC HISTORY IN THE AGRICULTURAL ERA (3)
456. AMERICAN ECONOMIC HISTORY IN THE INDUSTRIAL ERA (3) *Eggert*
457. HISTORY OF THE AMERICAN FRONTIER (3)
458. (L.S. 458) HISTORY OF AMERICAN ORGANIZED LABOR SINCE 1877 (3) *Eggert*
459. SOCIAL AND CULTURAL HISTORY OF THE UNITED STATES SINCE 1783 (3) *Brown*
460. UNITED STATES FOREIGN INTELLIGENCE (3) *Ameringer*
464. SPANISH CONQUEST OF THE NEW WORLD (3) *Garner*
465. LATIN AMERICAN INDEPENDENCE MOVEMENTS (3) *Garner*
467. LATIN AMERICA AND THE UNITED STATES (3) *Ameringer*
468. MEXICO AND THE CARIBBEAN NATIONS IN THE TWENTIETH CENTURY (3) *Ameringer*
471. HISTORY OF ARABIC CIVILIZATION, 600-1258 (3) *Goldschmidt*
472. THE OTTOMAN EMPIRE AND OTHER MUSLIM STATES (3) *Goldschmidt*
473. THE CONTEMPORARY MIDDLE EAST (3) *Goldschmidt*
477. HISTORY OF CENTRAL AND EAST AFRICA (3) *Griffith*
478. HISTORY OF WEST AFRICA (3) *Griffith*
480. THE HISTORY OF TRADITIONAL JAPAN (3)
481. THE HISTORY OF MODERN JAPAN (3)
483. TRADITIONAL CHINA TO 1800 (3) *Sun*
485. NINETEENTH-CENTURY CHINA (3) *Sun*
486. TWENTIETH-CENTURY CHINA (3) *Duiker*
488. TWENTIETH-CENTURY SOUTHEAST ASIA (3) *Duiker*
490. (L.St. 490) ARCHIVAL MANAGEMENT (1)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

501. HISTORICAL METHOD (3) *Meier and Utechin*
502. HISTORIOGRAPHY (3) *Borza and Meier*
503. STUDIES IN GREEK HISTORY (3-6) *Borza*
504. STUDIES IN ROMAN HISTORY (3-6) *Harvey*
509. MEDIEVAL CIVILIZATION (3-9) *Sweeney*
511. STUDIES IN MEDIEVAL ENGLISH HISTORY (3-6) A seminar in the political, economic, and cultural history of England in the Middle Ages.
515. THE AGE OF THE REFORMATION (3-6) *Spielvogel*
517. STUDIES IN EUROPEAN HISTORY, 1600-1750 (3-6) *Knight and Green*
519. STUDIES IN EUROPEAN HISTORY, 1750-1900 (3-6) *Knight and Silverman*
520. STUDIES IN TWENTIETH-CENTURY EUROPE (3-6) *Forster and Silverman*
530. SEMINAR IN EASTERN EUROPEAN HISTORY (3-6) *Enteen and Utechin*
533. STUDIES IN RUSSIAN AND SOVIET HISTORY (3-6) *Enteen and Utechin*

- 537. STUDIES IN BRITISH HISTORY (3-6) *Linker*
- 540. COLONIAL AND REVOLUTIONARY AMERICA (3-6) *Frantz*
- 543. THE UNITED STATES, 1783-1860 (3-6)
- 544. THE UNITED STATES, 1860-1877 (3-6) *Hassler*
- 545. THE UNITED STATES, 1877-1919 (3-6) *Eggert*
- 546. THE UNITED STATES SINCE 1919 (3-6) *Murray*
- 550. STUDIES IN CONSTITUTIONAL HISTORY (3-9) A graduate seminar examining constitutional developments in their historical context through readings, class discussions and research papers. *Stebbins*
- 553. DIPLOMATIC HISTORY OF THE UNITED STATES (3-6) *Maddox*
- 555. ECONOMIC HISTORY OF THE UNITED STATES (3-6) *Eggert*
- 559. CULTURAL HISTORY OF THE UNITED STATES (3-6) *Brown*
- 560. STUDIES IN PENNSYLVANIA HISTORY (3-6) *Frantz*
- 568. STUDIES IN THE HISTORY OF THE CARIBBEAN AREA (3 per term, maximum of 6) *Ameringer*
- 569. SEMINAR IN LATIN-AMERICAN HISTORY (3-6) *Ameringer*
- 573. STUDIES IN MIDDLE EASTERN HISTORY (3-6) *Goldschmidt*
- 583. STUDIES IN ASIAN HISTORY (3-9) *Sun and Duiker*
- 591. ARCHIVES PRACTICUM (3-6) Training and supervised work experience in archival activities — Option A: Archival Management; Option B: Oral History. Prerequisite: Hist. (L.St.) 490.
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

HOME ECONOMICS EDUCATION (HE ED)

TWYLA M. SHEAR, *In Charge of Graduate Programs in Home Economics Education*
212 Rackley Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members East, Ray, Shear, and Weis.

Graduate Faculty: Associate Members Murray and Thal.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

Students who have majored as undergraduates in some aspect of home economics and who have achieved a grade-point average of at least 2.50 in their junior and senior years will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Students wishing to be admitted to the doctoral programs must have completed a master's degree and will be admitted subject to limitations of departmental facilities. There is no foreign language requirement for degrees in the program.

HOME ECONOMICS EDUCATION (HE ED)

- 406v. AUDIO-VISUAL METHODS FOR HOME ECONOMICS (1-4)
- 427v. TEACHING HOME ECONOMICS (3)

- 463v. PRE-STUDENT-TEACHING SEMINAR (1)
 464v. POST-STUDENT-TEACHING SEMINAR (1)
 466v. STUDENT TEACHING (9)
 477v. CURRICULUM DEVELOPMENT FOR HOME ECONOMICS IN SECONDARY SCHOOLS (3)
 478v. APPRAISING STUDENT PROGRESS IN HOME ECONOMICS (3)
 480v. PROBLEMS IN TEACHING HOME ECONOMICS (3-6)
 481v. EMPLOYMENT PREPARATION PROGRAMS IN VOCATIONAL HOME ECONOMICS (3)
 482v. POSTSECONDARY, ADULT, AND CONTINUING EDUCATION PROGRAMS IN HOME ECONOMICS (3)
 496v. INDEPENDENT STUDIES (1-12)
 497v. SPECIAL TOPICS (1-6)
- 502, 502v. HOME ECONOMICS INSTRUCTION AT THE COLLEGE LEVEL (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers.
- 503, 503v. HOME ECONOMICS TEACHER EDUCATION (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics.
- 504, 504v. EDUCATIONAL ISSUES AND HOME ECONOMICS (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience.
- 510, 510v. EDUCATIONAL LEADERSHIP IN HOME ECONOMICS (2-6) Principles of educational leadership for home economists preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education major and two years' teaching experience in home economics.
- 511, 511v. INTERNSHIP IN HOME ECONOMICS SUPERVISION AND ADMINISTRATION (2-8) Opportunity to understudy an educational leader in student teacher supervision, state supervision, department or college administration, or regional consultation. Prerequisite: H.E.Ed. 510.
- 518, 518v. EVALUATION OF HOME ECONOMICS PROGRAMS (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision.
- 521, 521v. HOME ECONOMICS EDUCATION SEMINAR (2-3) Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.
- 530, 530v. PROBLEMS IN HOME ECONOMICS EDUCATION (1-6 per term) Individual investigation of problems related to the teaching, supervision, or administration of home economics education.
- 577v. CURRICULA IN HOME ECONOMICS (3) Development of curricula in home economics. Prerequisite: H.E.Ed. 477v.
- 602v. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

HORTICULTURE (HORT)

CRAIG R. OLIVER, *Acting Head of the Department*
 103 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Beelman, Bergman, Craig, Garwood, Grun, Martsolf, McArdle, Ritter, Shannon, Smith, Stinson, Tukey, and White.

Graduate Faculty: Associate Members Beattie, Cole, Daniels, Haeseler, Haramaki, Heuser, Holcomb, Kuhns, Mastalerz, Pfahl, and Wallner.

Students may specialize in several phases of production, plant genetics and breeding, soils and plant nutrition, horticultural physiology, post-harvest physiology, plant propagation, and microclimatology. Students wishing additional credits in the commodity areas of floriculture, olericulture, ornamental horticulture, and pomology, or in the areas of specialization listed above, should register for Hort. 501.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one of four options: (1) comprehensive competence in one language, (2) reading examination or two-course sequence in two languages, (3) reading examination or two-course sequence in one language plus 6 credits in other communications skills, or (4) 6 credits in each of two areas of communication skills.

Prerequisites for admission vary according to the area of specialization, but basic courses in physical sciences, mathematics, biological sciences, communication skills, and social sciences and humanities are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

HORTICULTURE (HORT)

- 401. PLANT PROPAGATION (3) *Haramaki*
 - 402. PLANT NUTRITION (3) *Bergman*
 - 403. HORTICULTURE PLANTS AND THEIR ENVIRONMENT (3) *Mastalerz*
 - 404. ADVANCED HORTICULTURE CROP SCIENCE (3-12)
 - 405. SENIOR SEMINAR IN HORTICULTURE (1-2)
 - 407. PLANT BREEDING (3) *Garwood*
 - 412. POST-HARVEST PHYSIOLOGY (3) *Wallner*
 - 444. ADVANCED PLANT BREEDING (3-6) *Craig*
 - 451. FLOWER STORE MANAGEMENT (4) *Pfahl*
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
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- 501. EXPERIMENTAL PROBLEMS IN HORTICULTURAL SCIENCE (1-12) Investigation of problems in floriculture, olericulture, ornamental horticulture, plant breeding, nutrition, or pomology.
 - 506. NUTRITION OF HORTICULTURAL CROPS (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Smith*
 - 512. PRINCIPLES OF FRUIT AND VEGETABLE STORAGE (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application. *Wallner*
 - 514. PROPAGATION AND IMPROVEMENT OF HORTICULTURE PLANTS (1-6) Biological factors affecting sexual and asexual propagation of plants; techniques in plant improvement; maintenance of propagation material. *Heuser*
 - 517. HORTICULTURE SEMINAR (1 per term) Review of current research publications in horticulture. Each student presents one or more reviews of assigned topics.
 - 520. GENETICS AND BREEDING SEMINAR (1 per term) Review of research and literature in genetics and breeding of horticultural crops.
 - 524. EXPERIMENTAL PROCEDURES IN HORTICULTURAL RESEARCH (3) *Craig*
 - 528. PROBLEMS IN FRUIT AND VEGETABLE PROCESSING (2-12) *McArdle*

HUMAN DEVELOPMENT AND FAMILY STUDIES (HD FS)

JOHN R. NESSELROADE, *In Charge of Graduate Programs in Human Development and Family Studies*
S-106 Henderson Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Baltes, Britton, Burgess, Danish, D'Augelli, de Lissovoy, Deutsch, Ford, Gottesman, B. Guernsey, L. Guernsey, Gunter, Hultsch, Huston, Knoll, Lerner, Liben, Nesselroade, Peters, Spanier, Taylor, Urban, Vondracek, and Walcher.

Graduate Faculty: Associate Members Anderson, Belsky, Getz, Goldberg, Hornblum, Nelson, Nottelman, Nowak, Schilmoeller, Seward, Smyer, Szinovacz, Treat, and Willis.

This interdisciplinary program is one of the graduate programs of the College of Human Development. It is administered through the Division of Individual and Family Studies. The program focuses on the developmental study of individuals, small groups, and families for the purposes of expanding basic knowledge and professional application. The perspective encompasses the individual life span, from infancy and childhood through later maturity and old age, as well as the full cycle of the family. For both individual and family, the perspective includes variations in functioning patterns and the use of resources; the impact of diverse social, economic, and cultural contexts upon behavior; conditions which promote adaptive individual, group, and family development; and the creation of techniques of accomplishing human development. Emphasis is upon the integration of knowledge from various fields for understanding and developing skills for careers in research and scholarship, teaching, program planning and evaluation, and other professional services. The faculty includes persons primarily in the behavioral and social sciences particularly committed to research and application in these multi- and interdisciplinary areas.

The student's program is expected to include work assuring both breadth in the major field and depth within one of three program areas: family development, human development intervention, or individual development. Further specialization is possible in adult development and aging, child and adolescent development, early childhood services, interpersonal relations, family economics and management, and family relationships.

Infant and early childhood laboratories are operated as part of the teaching and research program. Each unit has observational facilities and rooms for study of individual and group behavior of children and adults. The Individual and Family Consultation Center provides facilities for the development and evaluation of educational programs for remediation of individual and family problems by professional and paraprofessional persons. The Institute for the Study of Human Development, the Center for Health and Human Services, the Gerontology Center, the Center for Children, Youth, and the Family, and the Center for Community Research provide opportunities for participation in research and evaluation projects. Additional resources are available in other parts of the University.

A research and evaluation methodology core, required of all students, may be satisfied by selections from a variety of courses across the campus. Use may be made also of courses in other parts of the college and University to build substantive competence in the program. The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages. A minor or general studies group outside the major is required of all doctoral students.

Entering students should have at least 6 credits in the biological and physical sciences; 12 in the social sciences and, depending upon proposed area of emphasis, basic courses in sociology, psychology, and economics; and 6 in developmental and family studies. Students not meeting these requirements may be admitted with limited deficiencies to be made up concurrently with their graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission, which, with rare exception, will be for fall term only. Early application is required, and a special application to HDFS must be completed; additional information may be obtained from the professor in charge. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. The Graduate Record Examination is required of all applicants.

INDIVIDUAL AND FAMILY STUDIES (I F S)

- 410. COMMUNITIES AND FAMILIES (3)
- 411. THE HELPING RELATIONSHIP (3)
- 412. ADULT-CHILD RELATIONSHIPS (3)
- 413. DYSFUNCTIONS IN THE DEVELOPMENTAL PROCESS (3)
- 414. RESOLVING INDIVIDUAL AND FAMILY PROBLEMS (3)
- 415. PROGRAM DEVELOPMENT IN FAMILY RELATIONSHIPS (3)
- 416. (C.S. 416) CONSUMER ROLE OF FAMILY (3)
- 418. FAMILY RELATIONSHIPS (3)
- 419. PROBLEMS OF FAMILY FINANCIAL MANAGEMENT (3)
- 420. LABORATORY IN INDIVIDUAL AND FAMILY ENHANCEMENT (3)
- 424. ECONOMIC CONDITIONS IN RELATION TO THE FAMILY (3)
- 427. CONCEPTIONS OF DEVELOPMENT (3)
- 428. INFANT DEVELOPMENT (3)
- 429. ADVANCED CHILD DEVELOPMENT (3)
- 430. PRACTICUM IN PRESCHOOL GROUPS (1-6)
- 432. DEVELOPMENTAL PROBLEMS OF NORMAL CHILDREN (3)
- 435. DEVELOPMENTAL TRANSITION TO ADULthood (3)
- 442. HOME MANAGEMENT EXPERIENCE (3)
- 445. (Psy. 445) DEVELOPMENT THROUGHOUT ADULthood (3)
- 450. IMPLICATIONS OF DEVELOPMENTAL THEORIES FOR CHILD PROGRAMS AND SERVICES (3)
- 453. CHILD PROGRAMS AND SERVICES (3)
- 454. (C.&S. 454) DEVELOPMENT AND ADMINISTRATION OF CHILD SERVICE PROGRAMS (3)
- 470. (Psy. 470) SOCIAL LEARNING FOUNDATIONS OF BEHAVIOR CHANGE (3)
- 477. ANALYSIS OF FAMILY PROBLEMS (2-9)
- 490. INTRODUCTION TO FIELD EXPERIENCE (1)
- 491. DESIGN OF FIELD RESEARCH PROJECTS (2)
- 492. ADVANCED FIELD EXPERIENCE (1-10)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 500. NONTHESES RESEARCH (1-9)

- 501. SEMINAR: ISSUES IN THE STUDY OF INDIVIDUAL AND FAMILY DEVELOPMENT (1-3) Reading, reports, and discussion of conceptual frameworks for multidisciplinary and developmental study of individuals and families.

- 504. PRACTICUM IN PROGRAM DEVELOPMENT FOR PRESCHOOL CHILDREN (2-6) Investigation, analysis, and report on the design, development, and evaluation of a selected program for preschool children. Prerequisites: 6 credits of individual development and I.F.S. 430, 441.

- 506. PROJECTS IN DESIGN AND EVALUATION OF PROGRAMS FOR PRESCHOOL CHILDREN (2-4) Individual projects in the design, implementation, and evaluation of different teaching approaches with varying groups of children. Prerequisites: I.F.S. 504 and 3 credits in research methods.

- 508. PARENTAL EDUCATION (1-6) Implementing educational and preventive programs for parents; discussion and evaluation of theory and techniques.

- 511. MODIFYING CONJUGAL LIFE (1-9) Conceptual foundations, research procedures, and practicum experience in teaching effective communication and problem-solving skills in the marriage relationship. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.

- 512. FILIAL RELATIONSHIP MODIFICATION (1-9) Theory, research, and practicum in teaching parents to resolve developmental problems in their own children. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.

- 513. GROUP PROCEDURES IN INDIVIDUAL DEVELOPMENT (1-6) Theory, research, and practicum experience in the use of group methods for promoting individual development in different age groups. Prerequisites: I.F.S. 411 and research methods or statistics.

515. TEACHING INDIVIDUAL DEVELOPMENT AND FAMILY STUDIES (1-6) Objectives, techniques, materials, and evaluation in teaching at the secondary and college level, and in adult and public education programs.
520. SEMINAR IN PRENATAL AND INFANT DEVELOPMENT (1-6) Prenatal and infant development, with emphasis on multiple determinants of early development and their relationship to later behavior. Prerequisites: 6 graduate credits in individual development, psychology, or biological science and 3 credits in statistics.
522. SEMINAR IN DYSFUNCTION PROCESSES IN INDIVIDUAL DEVELOPMENT (1-6) Multiple processes involved in dysfunctional development in the individual across the life-span. Prerequisite: I.F.S. 413.
524. THEORETIC ANALYSIS OF FAMILY ECONOMIC AND MANAGERIAL BEHAVIOR (3) Conceptual approaches and major contributions to the study of the organizational, managerial, and economic functions of the family. Prerequisite: I.F.S. 418 or 424 or 477.
525. THEORIES OF FAMILY RELATIONSHIPS (3) Assessment of the utility of major theories for empirical analysis of interpersonal interactions among family members. Prerequisite: I.F.S. 418.
529. (Psy. 529) SEMINAR IN CHILD DEVELOPMENT (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.
530. INDEPENDENT STUDY IN INDIVIDUAL AND FAMILY STUDIES (1-9) Problems involving individual study. Prerequisite: instructor's approval of proposed study.
532. FIELD PROJECTS IN INDIVIDUAL AND FAMILY STUDIES (1-9) Supervised research or internship in human services program. Prerequisite: instructor's approval of proposed project.
536. (Psy. 536) RESEARCH METHODS IN DEVELOPMENTAL PROCESSES (3) Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology and a course in statistics.
539. SEMINAR IN ADOLESCENT DEVELOPMENT (1-6) Cultural, psychological, and biological aspects of the developmental transition to adulthood. Prerequisites: 6 credits in individual development or psychology and 3 credits in sociology and statistics.
543. MODIFICATION OF FAMILY MANAGERIAL PRACTICES (1-3) Conceptual issues, research, and practicum experience in assisting families in the solution of financial and managerial problems.
544. SEMINAR IN DYSFUNCTIONAL PATTERNS IN FAMILY ORGANIZATION (1-6) Processes of familial dysfunction and disorganization and their explanation in economic, social-psychological, and managerial terms. Prerequisite: I.F.S. 418 or 424 or Soc. 430.
545. FAMILIES AND SOCIOECONOMIC SYSTEMS (1-6) Functional interrelationships between families and social and economic systems. Prerequisites: I.F.S. 418, 424.
546. SEMINAR IN FAMILY RELATIONSHIPS (1-9) Interpersonal interaction within family systems throughout the life cycle. Prerequisite: I.F.S. 418.
549. (Psy. 549) DEVELOPMENTAL THEORY (3) Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.
550. SEMINAR IN FAMILY ECONOMICS AND MANAGEMENT (1-6) Recent developments in the study of family economic and managerial practices.
579. SEMINAR IN ADULT DEVELOPMENT AND AGING (1-9) A seminar dealing with specific topics concerning adult development and aging. Prerequisites: I.F.S. 445 and statistics.
590. COLLOQUIUM (1-3)
597. SPECIAL TOPICS (1-6)

HUMANITIES (HUMAN)

ROBERT J. GRAHAM, *Program Head, Humanities*
The Capitol Campus, Middletown, PA 17057

Degree Conferred: M.A.

Graduate Faculty: Senior Members Dordevic, R. Graham, Richman, Tischler, G. Wolf, and M. Wolf.

Graduate Faculty: Associate Members Churchill, T. Graham, Haber, Mahar, and K. Sweeney.

Defining humanities as the study of men and societies through examinations of their arts, this program aims at developing skills for the interdisciplinary study of art, music, literature, philosophy, and related fields such as photography, film, dance, and theater. Entering students are expected to have studied in at least two of the major areas. Exceptions may be made for students with special backgrounds and abilities who are committed to attaining competence in a second area. A supervisory committee meets with each student to determine individual needs and arrange a program designed to develop skills for the formal analysis of works; for analysis based on various critical perspectives; for evaluation of works by applications of appropriate criteria; and for the perception of relationships between styles, media, periods, and cultures. For students who plan to teach in a junior or community college, there is also provision for an internship option following the completion of most degree requirements.

A series of six 500-level courses is designed to help a student develop a number of the program skills. In addition, the adviser may suggest enrollment in certain 400-level courses or in independent studies with qualified faculty. The degree program requires completion of 18 credits at the 500 level.

To qualify for the M.A. in humanities, the student must demonstrate competence in applying the methods of humanistic inquiry to a relevant subject area. Course work and independent study will help in the development of the appropriate skills and the acquisition of necessary knowledge, but the degree is not awarded in recognition of a set total number of course credits having been compiled; the degree testifies that the recipient has cultivated the necessary skills of analysis and synthesis and has successfully completed a scholarly or creative master's production.

Ordinarily, a full-time student can expect to complete the program in four terms, a part-time student in six to nine terms.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is available only at the Capitol Campus.

HUMANITIES (HUMAN)

500. RESEARCH METHODS (3) Study of the methods and materials of scholarship, compilation of bibliographies, writing of scholarly papers, and proper documentation.

502. PERENNIAL ISSUES IN THE HUMANITIES (3) Recurrent issues viewed in terms of their significance to the artist, historian, and the philosopher.

503. INTERRELATIONS IN THE HUMANITIES (3) An interdisciplinary study of the interdependence of aesthetic values in various art forms as they exist in cultural settings. Prerequisite: Human. 500.

520. STUDIES IN STYLE (3) Study of prominent stylistic patterns, evaluating the essence of a style, and the varied responses of the artist and philosopher within a pattern.

525. STUDIES IN AESTHETICS (3) Study of certain techniques in the arts that presuppose certain aesthetic concepts and certain ideas that demand parallel form.

580. MASTER'S PRODUCTION (1-6) An original scholarly master's paper or creative production initiated by the student, supervised by an appropriate professor, and judged by a committee.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

Additional courses may be taken from the following list and at the 400- or 500-level in related fields with the concurrence of the student's adviser.

- Am.St. 452 THE AMERICAN RENAISSANCE
- Am.St. 455 AMERICAN PHILOSOPHY
- Am.St. 459 AMERICA'S COMING OF AGE 1914-1939
- Am.St. 460 AMERICAN ART AND ARCHITECTURE
- Am.St. 461 AMERICAN ART AND ARCHITECTURE OF THE NINETEENTH CENTURY
- Am.St. 463 AMERICAN MUSIC
- Art 415 STUDIO ART
- Art 420 CRITICAL APPROACHES TO ART
- Art 427 MASTERS OF ART
- Art 440 TRENDS IN ART
- Human. 405 THE STUDY OF INTELLECTUAL AND CULTURAL HISTORY
- Human. 408 COMPARATIVE STUDY OF RELIGIOUS LITERATURE
- Human. 409 MYTH AND CHILDREN'S LITERATURE
- Human. 410 RELIGION AND LITERATURE
- Human. 430 PHILOSOPHY AND LITERATURE
- Human. 441 MYTH, SYMBOL, AND RITUAL
- Human. 453 LITERATURE AND SOCIETY
- Human. 460 THEMATIC STUDIES
- Human. 461 SELECTED PERIODS IN THE HUMANITIES
- Lit. 427 MASTERS OF LITERATURE
- Lit. 440 FORM AND FUNCTION
- Lit. 450 CULTURAL PATTERNS IN LITERATURE
- Lit. 460 LITERARY PERIODS
- Lit. 461 STUDIES IN LITERARY STYLE
- Music 427 MASTERS OF MUSIC
- Music 440 FORMS IN MUSIC
- Music 460 STUDIES IN MUSICAL STYLE
- O.S. 410 CHINESE PHILOSOPHY AND WESTERN THOUGHT
- O.S. 455 ORIENTAL CULTURE
- Phil. 415 AESTHETICS
- Phil. 431 PHILOSOPHICAL PERSPECTIVES
- Phil. 440. READING OF AN INDIVIDUAL PHILOSOPHER
- Phil. 445 SOCIAL-POLITICAL PHILOSOPHIES
- Phil. 447 PHILOSOPHICAL PERIODS
- Phil. 490 PHILOSOPHICAL TOPICS
- Thea. 406 STUDIES IN THEATRE
- Ed. 520 SEMINAR IN JUNIOR COLLEGE TEACHING
- Ed. 550 INTERNSHIP IN JUNIOR COLLEGE

INDUSTRIAL ENGINEERING (I E)

WILLIAM E. BILES, *Head of the Department of Industrial and Management Systems Engineering*
207 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Biles, Callahan, Draper, Enscoe, Guild, Ham, Ignizio, Raphael, and Rosenshine.

Graduate Faculty: Associate Members Creese, Davis, Freark, Fugelso, Goodrich, Kozik, Olsen, Thuering, and Zindler.

Graduate study and research are conducted in operations research-management science, production engineering, process design, systems engineering, and human engineering.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of one foreign language (Russian, German, French, or Japanese).

Graduates in industrial engineering, other engineering curriculums, and mathematics who present a 2.50 junior-senior average will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

INDUSTRIAL ENGINEERING (I E)

- 400. ENGINEERING FOR PRODUCTION (3)
 - 402. ENGINEERING ECONOMY (3)
 - 403. ENGINEERING ECONOMY AND STATISTICS (3)
 - 404. MANAGEMENT SCIENCE (3)
 - 405. LINEAR PROGRAMMING (3)
 - 406. DESIGN OF PRODUCTION AND DISTRIBUTION SYSTEMS (3)
 - 407. QUANTITATIVE METHODS FOR OPERATIONS RESEARCH (3)
 - 408. HUMAN FACTORS ENGINEERING (3)
 - 414. MATERIALS JOINING PROCESSES AND PRINCIPLES (3)
 - 423. QUALITY CONTROL (3)
 - 424. PROBLEMS IN PERSONNEL MANAGEMENT (3)
 - 425. INTRODUCTION TO OPERATIONS RESEARCH (3)
 - 426. INDUSTRIAL AUTOMATION (3)
 - 427. SOLIDIFICATION OF CASTINGS (3)
 - 428. FOUNDRY ENGINEERING (3)
 - 432. INTRODUCTION TO RELIABILITY ENGINEERING (1-3)
 - 438. METAL CUTTING PRINCIPLES AND PRACTICE (3)
 - 439. ENGINEERING SYSTEMS OPTIMIZATION (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
501. MANUFACTURING METHODS (2-8) Special projects including investigation, experimentation, design, and research of one or more special types of manufacture.
503. INDUSTRIAL RELATIONS (1-6) Study of human problems related to labor unions, hierarchy, specialization; analysis of organizational structure, policies, decision criteria, and communication systems.
506. ADVANCED WORK DESIGN AND MEASUREMENT (3-9) Methods of research in motion and time study; critical analysis of current literature.
507. OPERATIONS RESEARCH: SCHEDULING MODELS (3) Scheduling models with simultaneous job arrival and probabilistic job arrival, network scheduling and scheduling simulation techniques. Prerequisite: I.E. 425.
508. OPERATIONS RESEARCH: INVENTORY MODELS (3) A study of inventory theory, deterministic models, probabilistic models, multiproduct models in both the single and multiperiod modes. Prerequisite: I.E. 425.
509. OPERATIONS RESEARCH: WAITING LINE MODELS (3) Waiting line models including models with infinite queues, finite queues, single and multiple servers under various priorities and disciplines. Prerequisite: I.E. 425.
510. MATHEMATICAL PROGRAMMING (3) Study of advanced topics in linear programming including duality, decomposition, sensitivity analysis, parametric programming, and selected topics in mathematical programming. Prerequisite: I.E. 405.

511. **EXPERIMENTAL DESIGN IN ENGINEERING (3)** Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisite: I.E. 323.
512. **GRAPH THEORY AND NETWORKS IN MANAGEMENT SCIENCE (3)** Prerequisite: I.E. 425.
513. **REAL TIME DATA PROCESSING FOR ENGINEERING SYSTEMS (3)** Random access computers and communication components for real time systems; engineering systems simulation on digital computers. Prerequisite: Cmp.Sc. 102 or 410.
515. **COMPLEX LINEAR FLOW MODELS (3)** Application of complex linear flow models in engineering and management science, including static and dynamic system simulations. Prerequisite: I.E. 405.
516. **APPLIED STOCHASTIC PROCESSES I (3)** Prerequisite: Stat. (Math.) 427.
517. **APPLIED STOCHASTIC PROCESSES II (3)** Prerequisite: I.E. 516.
518. **PLASTIC DEFORMATION PROCESSES (3)** Study of the principles, theories, technology, design, and application of plastic deformation processes to shape metals. Prerequisite: undergraduate engineering degree.
519. **DYNAMIC PROGRAMMING (3)** Study of the concepts underlying model-building and optimization of dynamic systems with application to engineering, economic, and environmental systems. Prerequisites: I.E. 405 or Q.B.A. 451; Stat. 418.
520. **GOAL PROGRAMMING (3)** Study of concepts and methods in analysis of systems involving multiple objectives with applications to engineering, economic and environmental systems. Prerequisite: I.E. 405 or Q.B.A. 451.
528. **METAL CUTTING THEORY (3)** Study of the theory of metal cutting, contemporary and future problems of metal removal processes; critical analysis of current literature. Prerequisite: I.E. 438.
538. **EXPERIMENTAL INVESTIGATIONS IN MATERIALS PROCESSING (3)** Experimental investigation on selected subjects in processing involving instrumentation, methods, and analysis. Prerequisite: I.E. 528.
597. **SPECIAL TOPICS (1-6)**
596. **INDIVIDUAL STUDIES (1-6)**

JOURNALISM (JOURN)

DANIEL W. PFAFF, *In Charge of the Graduate Program in Journalism*
218 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty: Senior Member Blanchard.

Graduate Faculty: Associate Members Berner, Dulaney, Froke, Goodwin, McGlashan, Norris, Pfaff, Rippey, Smith, Tenney, and Zanot.

The one-year program is intended to serve two kinds of students: those who enter with several years of media work experience who are interested in improving their job marketability or in broadening the range of their professional abilities, and those with little or no media experience who are interested in preparing for a career in journalism. Experienced persons will be required to earn from 30 to 33 credits in prescribed course work and electives. Those without experience will take 33 to 36 credits of course work and electives. Experienced persons will have more latitude in course selection than those without experience. In individual cases, it may be possible for a candidate to take up to 9 credits of work outside the School of Journalism. In all cases, the program must be substantially completed in twelve months.

Students with a 3.00 junior-senior average are eligible for admission. Those with lower averages who have significant professional experience or other unusual qualifications also will be considered. Two letters of recommendation are required. They should be from persons closely familiar with the ap-

plicant's professional background and competencies. The Graduate School requires all applicants to submit copies of their Graduate Record Examination scores. Applicants must submit an autobiographical statement of about 1,000 words indicating the nature of the applicant's interest in journalism or mass communications, reasons for wanting to do graduate work, and aspirations for the future.

JOURNALISM (JOURN)

- 401. MASS MEDIA IN HISTORY (3)
- 403. LAW OF MASS COMMUNICATIONS (3)
- 405. POLITICAL ECONOMY OF COMMUNICATIONS (3)
- 407. ADVERTISING IN CONTEMPORARY SOCIETY (3)
- 409. CRITICS AND ETHICS OF THE MASS MEDIA (3)
- 411. CULTURAL ASPECTS OF THE MASS MEDIA (3)
- 413. THE MASS MEDIA AND THE PUBLIC (3)
- 415. CURRENT ISSUES IN ADVERTISING (3)
- 416. (Engl. 416) SCIENCE WRITING (3-6)
- 417. ADVERTISING AND CONSUMERISM (3)
- 419. (Sp.Com. 419) COMPARATIVE BROADCASTING SYSTEMS (3)
- 421. PUBLIC AFFAIRS REPORTING (3)
- 423. REPORTING OF CONTEMPORARY ISSUES (3)
- 425. NEWS EDITING AND EVALUATION (3)
- 426. REPORTING BUSINESS AND ECONOMIC NEWS (3)
- 427. MAGAZINE JOURNALISM (3)
- 429. EDITORIAL INTERPRETATION (3)
- 436. (Soc. 436) SOCIOLOGY OF OPINION FORMATION (3)
- 441. ADVERTISING COMMUNICATIONS PROBLEMS (3)
- 443. ADVERTISING MEDIA PLANNING (3)
- 445. ADVERTISING CAMPAIGNS (3)
- 451. PUBLIC RELATIONS (3)
- 453. PUBLIC RELATIONS PROBLEMS (3)
- 461. PHOTOGRAPHY FOR THE MASS MEDIA (3)
- 473. INTERNATIONAL MASS COMMUNICATIONS (3)
- 475. EVALUATION AND USES OF MASS COMMUNICATIONS RESEARCH (3)
- 477. JOURNALISM IN THE SCHOOLS (3-6)
- 485. INTERNSHIP (1-9)
- 487. (Sp.Com. 487) MASS COMMUNICATIONS STUDY ABROAD (1-9)
- 492. PUBLIC AFFAIRS BROADCASTING (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 504. SEMINAR IN THE HISTORY OF MASS COMMUNICATION (3)
- 505. INTERNATIONAL COMMUNICATION PROBLEMS (3) Legal and communications problems of the international flow of news and opinion; international press codes.
- 506. INTRODUCTION TO MASS COMMUNICATIONS RESEARCH (3) The scientific method; survey of basic concepts of theoretical and empirical research; variety of methodology; criteria for adequate research.
- 508. THE LITERATURE OF JOURNALISM (3)
- 511. MASS COMMUNICATIONS RESEARCH METHODS II (3) Problems of bibliographical research; evaluation of sources and materials in mass communications history, biography, structure, ethics, and other areas. Prerequisite: Journ. 506.
- 513. CONSTITUTIONAL PROBLEMS OF THE NEWS MEDIA (3) Problems involving conflict between guarantees of press freedom in the First and Fourteenth Amendments and rights and privileges of others.

521. NEWS MEDIA AND PUBLIC OPINION (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion.
524. GOVERNMENT AND MASS COMMUNICATIONS (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Smith*
540. SEMINAR IN ADVERTISING PROBLEMS (3) *Norris*
585. COMPARATIVE THEORIES OF PRESS SYSTEMS (3) Institutional structure and normative functions of press systems in modern societies, as shaped by prevailing world view and social organization. *Norris*
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

LABORATORY ANIMAL MEDICINE (L A M)

C. MAX LANG, *Chairman of the Department of Comparative Medicine*
The Milton S. Hershey Medical Center
Hershey, PA 17033

Degree Conferred: M.S.

Graduate Faculty: Senior Members Bullock and Lang.

Graduate Faculty: Associate Members Hughes and White.

The department offers a postdoctoral program for veterinarians leading to the Master of Science degree with a major in laboratory animal medicine. Laboratory animal medicine is a specialty of veterinary medicine that is concerned with the biology of laboratory animals and their comparative relationships to man. Postdoctoral training in this discipline provides a broad, basic foundation upon which the individual can build a career in teaching and research in laboratory animal medicine and/or in the professional direction of research animal facilities. The program has a strong research-oriented base with emphasis on comparative medicine and pathology.

The program requires two years for completion. Basically, the first year consists of formal course work, while the second year is devoted mainly to research and the development of clinical skills and techniques. A student must have earned a minimum of 12 credits in a major subject, 6 credits in a minor subject, and 6 credits of thesis research in order to receive the graduate degree. Approved minors have been established in anatomy, behavioral science, biological chemistry, microbiology, pathology, pharmacology, and physiology.

Students with a 3.00 junior-senior average, with a doctor of veterinary medicine degree, and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is offered only at The Milton S. Hershey Medical Center.

COMPARATIVE MEDICINE (C MED)

501. BIOLOGY AND CARE OF LABORATORY ANIMALS (2) Presentation of the anatomic and physiologic characteristics of the commonly used laboratory animal species and their relation to biomedical research.
503. LABORATORY ANIMAL GENETICS (2) Genetic principles applied to laboratory animals used for investigations of diseases that may be controlled or influenced by genetic factors.
505. LABORATORY ANIMAL ZOONoses (2) Experimentally induced, spontaneous, and infectious diseases transmissible between man and animals, with special emphasis on etiology, differential diagnosis, and control.

507. **TECHNIQUES OF LABORATORY ANIMAL EXPERIMENTATION (2)** Techniques of drug administration, infusion, and collection of body fluids and materials; gnotobiology; use of radioisotopes and bioinstrumentation.
510. **ANIMAL PHYSIOLOGICAL SURGERY (3)** Selected operative procedures, demonstrating principles of physiology with modern biomedical instrumentation, will be followed through the postoperative period.
515. **EXPERIMENTAL SURGERY OF LABORATORY ANIMALS (3)** Surgical techniques, including nephrectomy and Goldblatt clamp, bladder and gastric pouches, bile duct cannulation, intraventricular operation, cardiac and cerebrovascular catheterization.
530. **DISEASES OF LABORATORY ANIMALS I (3)** Physiological and pathological expressions of both infectious and metabolic-degenerative diseases of rodents, with emphasis on diagnostic and control methods.
531. **DISEASES OF LABORATORY ANIMALS II (3)** Physiological and pathological expressions of both infectious and metabolic-degenerative diseases of nonhuman primates and other species of animals.
535. **COMPARATIVE PATHOLOGY (3)** Comparative pathologic characteristics of infectious and metabolic disease of animals and man.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

LINGUISTICS (LING)

SIMON BELASCO, *In Charge of Graduate Programs in Linguistics*
310 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Baldi, Belasco, Brault, Brubaker, Dalbor, Ebbinghaus, Holtzman, Magner, Martin, Morrill, Palermo, Schmalstieg, and Sturcken.

Graduate Faculty: Associate Members Buckalew, Higgs, and Smaby.

A student majoring in linguistics may specialize in one of several flexible interdisciplinary graduate programs. The M.A. degree program includes general courses in historical linguistics, generative phonology and syntax, psycholinguistics, and acoustic phonetics. A candidate will also select, with the help of the graduate adviser, a coherent set of electives in a specialized area which may be a language or a related field. An acceptable thesis or paper must be submitted and a written comprehensive examination passed.

In addition to the courses required for the M.A. degree in linguistics (or the equivalent), each candidate for the Ph.D. degree must take the following courses: Ling. 503 if Ling. 504 is selected; Ling. 505 (Seminar in Historical Linguistics), Sp.Com. 520 (Seminar in Speech Science), and at least two 500-level courses in the structure, phonology, and history of a language or language family other than the native language if the specialty is in a related area, and at least five 500-level courses in the related area. If the specialty is in a language area, the student must take at least two 500-level courses in the structure, phonology, and history of a language or language family other than the native language or language area and at least five 500-level courses in the chosen language area. The specialized area will be selected by the candidate with the approval of the doctoral committee. The doctoral comprehensive examinations will be both written and oral and will cover the synchronic and diachronic aspects of general linguistics as well as the candidate's specialized area. The thesis must represent a significant contribution to linguistic knowledge. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of either French, German, Spanish, or Russian, and another major language related to the candidate's professional interests.

The minimum requirement for admission to an advanced degree program will normally be a B.A. degree in linguistics or an equivalent in any of the interdisciplinary subjects recognized as a specialized area.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

LINGUISTICS (LING)

- 400. INTRODUCTION TO TRANSFORMATIONAL GRAMMAR (3)
- 401. INTRODUCTION TO LINGUISTIC THEORIES (3)
- 402. HISTORICAL LINGUISTICS (3)
- 404. GENERATIVE PHONOLOGY (3)
- 413. (Sp.Com. 413) EXPERIMENTAL LINGUISTICS (3)
- 415. CONTRASTIVE ANALYSIS (3)
- 420. (Psy. 420) ADVANCED PSYCHOLINGUISTICS (3)
- 448. LANGUAGE VARIATION (3)
- 449. PROBLEMS IN TRANSFORMATIONAL SEMANTICS (3)
- 451. HISTORY OF THE GREEK LANGUAGE (3)
- 461. (Latin 461) HISTORY OF THE LATIN LANGUAGE (3)

- 500. GENERATIVE LINGUISTICS (3) Types of grammatical rules and their interrelations; algorithm for assigning structural descriptions; evaluation procedure for selecting best compatible grammar.
- 503. GENERATIVE SYNTAX (3) Grammatical rules specifying well-formed strings; conditions on analyzability and assigning of structural descriptions; deviation from well-formedness. Prerequisite: Ling. 400.
- 504. GENERATIVE PHONOLOGY (3) Distinctive feature theory in the generative framework; articulatory and acoustic correlates; nonphonemic features. Prerequisite: Ling. 400.
- 505. SEMINAR IN HISTORICAL LINGUISTICS (3) Detailed study of some problem of historical linguistics, e.g., the laryngeal theory, Indo-European ablaut, etc. Prerequisite: one course in historical linguistics.
- 517. (S.P.A. 517) APPLICATIONS OF LINGUISTICS TO COMMUNICATION DISORDERS (1) Application of linguistic theory to the understanding of communication disorders, with clinical implications for speech and language therapy. Prerequisites: 12 credits in speech pathology and audiology, psychology, linguistics, or phonetics.
- 520. (Psy. 520) SEMINAR IN PSYCHOLINGUISTICS (3) Consideration of theoretical and research issues relevant to psychological aspects of language sounds, syntax and semantics, and other cognitive support.
- 595. SEMINAR IN INTERDISCIPLINARY LINGUISTICS (3-12) Methods of research. Common and individual investigations in interdisciplinary fields of linguistics in consultation with one or more interdisciplinary instructors. Prerequisite: Ling. 400.
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

MAN-ENVIRONMENT RELATIONS (M E R)

SIDNEY COHN, *Director of the Division*
S-126 Henderson Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Everett, Lawton, Mann, Patterson, Powers, Studer, Vallance, and Wohlwill.

Graduate Faculty: Associate Members Cohn, Griffin, and Loukissas.

The Division of Man-Environment Relations has two degree programs, one leading to the Ph.D. degree in man-environment relations and the other to the D.Ed. degree in food service management.

The objective of the Ph.D. degree program in man-environment relations is to seek, through a broad-based analysis of complex environmental problems, an integrated understanding of man-environment systems, and to develop appropriate methods to plan and manage these systems. The multidisciplinary program is concerned with the analysis of the effects of the physical environment upon human psychological, social, and biological functioning, and with the development of methods for organizing planned systems in response to social and behavioral goals. The research and instructional activities in the program focus on: (1) the relation of behavior to characteristics of environmental settings such as schools, housing and recreational facilities, and urban neighborhoods and communities; (2) environment-behavior relations in such functional systems as health care and transportation; and (3) the effects of planned intervention in the environment on individual and social behavior. These problems are considered with reference to the population in general, as well as special groups such as children, the aged, and the handicapped.

The program trains scientists for problem-oriented research dealing with environment-behavior systems. Instruction emphasizes the application of disciplinary information to problems arising from man's interaction with the physical environment. Doctoral students in the program are expected to acquire skills in a wide range of research and intervention methods and in techniques and theoretical perspectives of man-environment relations, and to develop the competency to generate applied research contributing to a body of knowledge of benefit to the design fields and social science alike.

Providing the appropriate multidisciplinary perspective are faculty with backgrounds in such fields as architecture, city and regional planning, operations research, urban design, social and experimental psychology, organizational behavior, and business administration. In addition to these full-time faculty, the division has available the resources of a group of adjunct faculty in diverse fields related to man-environment relations.

Recent graduates have taken positions with governmental and private research organizations dealing with environmental facilities, services, and problems and with colleges and universities with departments of architecture, planning, psychology, and environmental and urban studies.

Relevant undergraduate preparation may be in the design and planning professions, environmental and urban studies, and other programs in the physical, social, or behavioral sciences appropriate to the study of man-environment systems. Students with a 3.00 junior-senior grade-point average will be considered for admission. Exceptions to the minimum 3.00 average may be made for students with special backgrounds, abilities, and interests.

The division offers an M.S. degree for those entering the program without a master's degree but does not consider it a terminal degree.

Students in the Ph.D. program may elect the dual-title degree program in operations research for the Ph.D. and M.S. degrees (see page p. 238).

The D.Ed. degree program in food service and housing administration equips its students to meet the critical need for educators qualified to staff programs and serve as department heads in hospitality education. The program has been designed to develop professional leadership in the field of hospitality education through a combination of study, research, and teaching experience. The applicant should possess a master's degree in food service and housing administration or a similar academic course of study. The course work leading toward the degree can be arranged to reflect the individual student's interests and prior educational experience. Although the course work can be drawn from appropriate disciplines throughout the University, the research emphasis focuses predominantly on food service administration and travel and lodging management.

MAN-ENVIRONMENT RELATIONS (M E R)

- 414. PLANNING COMMUNITY ENVIRONMENTS (3)
- 435. (Psy. 435) ENVIRONMENTAL STIMULATION AND BEHAVIOR (3)
- 442. ANALYTIC METHODS IN MAN-ENVIRONMENT RELATIONS II (3)
- 447. (Soc. 447) ENVIRONMENTAL SOCIOLOGY (3)
- 452. MAN-ENVIRONMENT RELATIONS LABORATORY II (3)
- 453. MAN-ENVIRONMENT RELATIONS LABORATORY III (3)
- 471. HOUSING SPACE RELATED TO LIVING PATTERNS (3)
- 472. HOUSING PROBLEMS AND POLICIES (3)
- 480. METHODS FOR THE DESIGN OF ENVIRONMENT-BEHAVIOR SYSTEMS (3)
- 481. MANAGEMENT METHODS FOR ENVIRONMENT-BEHAVIOR SYSTEMS (3)
- 482. PLANNING METHODS FOR ENVIRONMENT-BEHAVIOR SYSTEMS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 500. NONTHESIS RESEARCH (1-6)
- 501. PROBLEMS IN MAN-ENVIRONMENT RELATIONS (1-9) Individual directed study, investigation, and practice in selected aspects of man-environment relations.
- 502. SEMINAR IN MAN-ENVIRONMENT RELATIONS (1-9)
- 503. RESEARCH METHODS AND EVALUATION IN MAN-ENVIRONMENT RELATIONS (1-9)
- 505. ENVIRONMENTAL-BEHAVIORAL PROGRAMMING, DESIGN, AND MANAGEMENT (3) Applications of findings in the behavioral sciences to environmental design and management strategies; empirical, theoretical, and methodological issues.
- 510. PSYCHOLOGICAL FOUNDATIONS OF THE STUDY OF ENVIRONMENT-BEHAVIOR RELATIONS (3) Seminar relating the psychology of perception, cognition, motivation, personality, attitude formation, and psychological stress to aspects of the physical environment.
- 512. BEHAVIOR ANALYSIS OF ENVIRONMENTAL PROBLEMS (3) Analysis of behaviors contributing to environmental dysfunction. Behavior change strategies are proposed to deal with such problem areas as transportation, pollution, overpopulation.
- 515. ENVIRONMENTAL SYSTEMS THEORY (3) An in-depth review of those elements of general systems theory relevant to the analysis and organization of man-environment settings.
- 516. QUANTITATIVE METHODS IN ENVIRONMENTAL MANAGEMENT (3) The use of operations research and systems analysis in the modeling of man-environment systems. Prerequisite: M.E.R. 515.
- 520. RECENT DEVELOPMENTS IN TEXTILES (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.
- 523. SOCIETAL DETERMINANTS IN CLOTHING AND TEXTILE DEVELOPMENT (1-6)
- 534. (Stat. 534) DYNAMIC PROGRAMMING (3) The study of the concepts underlying model-building and optimization of dynamic systems; applications to engineering, economic, and environmental systems. Prerequisites: Stat. 418; I.E. 405 or Q.B.A. 451.
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

- 402. FOOD SERVICE AND HOUSING LAYOUT AND DESIGN (3)
- 410. ADVANCED QUANTITY FOOD PRODUCTION (3)
- 412. FOOD AND BEVERAGE OPERATIONS (3)
- 435. FINANCIAL MANAGEMENT IN HOSPITALITY INDUSTRIES (3)
- 442. HOSPITALITY MERCHANDISING (3)
- 461. PERSONNEL FUNCTIONS IN FOOD SERVICE AND HOUSING ADMINISTRATION (3)

470. PROBLEMS IN FOOD SERVICE AND HOUSING ADMINISTRATION (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)

MATHEMATICS (MATH)

GERALD LALLEMENT, *In Charge of Graduate Programs in Mathematics*
 227 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Andrews, Armentrout, Axt, C. Ayoub, R. Ayoub, Deutsch, Farrell, Glasner, Hahn, Herman, Hunter, James, Jech, Kanwal, Krall, Lallement, Maserick, Morris, Olson, Parsons, Rung, Simpson, Stevens, Waterhouse, Wells, and Yood.

Graduate Faculty: Associate Members G. Anderson, J. Anderson, Brownawell, Buhler, Chen, P. Chowla, Formanek, Fulton, Huff, Mansfield, McCammon, Mills, O'Sullivan, Sibley, Ware, and Weisfeiler.

Graduate courses in all the principal branches of mathematics are offered regularly each year. The department is prepared to direct research in a variety of fields, including various branches of analysis, algebra, topology, number theory, applied analysis, and mathematical logic and foundations.

To be admitted to the Ph.D., D.Ed., or M.A. program without undergraduate deficiency, an applicant should have completed at least 18 credits in mathematics at the advanced undergraduate level (400 series or their equivalents). The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421), 6 in modern algebra (Math. 480-481), and 3 in topology (Math. 429) or their equivalents. These courses are essential preparation for the graduate program, and if they are taken after admission, a maximum of 6 credits may be counted toward an advanced degree.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

All Ph.D. students must take qualifying examinations in three fields of mathematics. Normally these examinations are taken before the beginning of the third year of graduate study. Recommendations for advancement to Ph.D. candidacy are based on these examinations together with performance in the first two years of study. The comprehensive examination is given after approximately 60 credits are earned and after the student has passed reading examinations in two languages chosen from French, Russian, or German. The Ph.D. student is also expected to enroll in advanced seminars.

Outstanding students who do not continue in the doctoral program may petition the department for further support in order to pursue a second master's degree in another area to which mathematics is applicable.

For the D.Ed. degree, a student must pass qualifying examinations in algebra and analysis and a reading examination in French, German, or Russian before taking the comprehensive examination. In addition to the major thesis, the department requires participation in two terms of research seminar, but no minor thesis is required. The D.Ed. program is intended for college teachers. Three years of experience in professional mathematics teaching on a full-time basis is required for admission. (Graduate teaching assistants are not included in this category.)

For the M.A. degree the department offers two options: (1) the thesis option requires 12 credits of approved 500-series courses in mathematics, 6-9 credits of thesis, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a final oral examination based on the thesis and general course material; and (2) the nonthesis option requires 18 credits of 500-series courses in mathematics with a grade of A or B, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a term paper on an approved topic in mathematics. No final examination is given in this option. A student choosing the program option in operations research must complete a thesis.

To be admitted to the M.Ed. program without undergraduate deficiency, an applicant should have completed at least 15 credits in mathematics at the intermediate level beyond calculus. The M.Ed. program does not require any 500-series courses, but the student is encouraged to select some at this level.

Special courses have been instituted for the training of teachers. Among these are Math. 400, 401-402, 416, 425-426, and 470-471. These are acceptable for the satisfaction of credit requirements only for the M.Ed. degree.

Entering graduate students in mathematics for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. Furthermore, the results of this examination must be received by the Department of Mathematics at least six months prior to the requested date of admission to the Graduate School.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.A. degrees (see p. 238).

A brochure describing more fully the graduate program in mathematics is available from the Department of Mathematics.

MATHEMATICS (MATH)

- 400. PROBABILITY FOR TEACHERS (3)
- 401. GEOMETRY FOR TEACHERS (3 EACH)
- 404. THEORY OF NUMBERS (3)
- 406. TOPICS IN THEORY OF NUMBERS (3)
- 409. (Stat. 409) INTRODUCTION TO PROBABILITY THEORY (3)
- 410. (Stat. 410) MATHEMATICAL STATISTICS I (3)
- 411. FINITE DIFFERENCES (3)
- 412. (Stat. 412) MATHEMATICAL STATISTICS II (3)
- 414. MATHEMATICS OF SCIENCE FOR TEACHERS (3)
- 416. MATHEMATICAL LOGIC FOR TEACHERS (3)
- 417. (A.M. 417) TENSOR ANALYSIS (3)
- 418. (A.M. 418, Stat. 418) DISCRETE PROBABILITY THEORY (3)
- 419. (A.M. 419, Phys. 419) THEORETICAL MECHANICS (3)
- 420. INTRODUCTION TO ANALYSIS I (3)
- 421. INTRODUCTION TO ANALYSIS II (3)
- 422. ALGEBRAIC GEOMETRY (3)
- 423. METRIC DIFFERENTIAL GEOMETRY (3)
- 425-426. ANALYSIS FOR TEACHERS (3 each)
- 427. (Stat. 427) DISCRETE STOCHASTIC MODELS (3)
- 428. (Phil. 428) LOGICAL THEORY (3)
- 429. GENERAL TOPOLOGY (3)
- 430. ELEMENTARY ALGEBRAIC TOPOLOGY (3)
- 431. (A.M. 431) ORDINARY DIFFERENTIAL EQUATIONS (3)
- 432. (A.M. 432) FOURIER SERIES AND PARTIAL DIFFERENTIAL EQUATIONS (3)
- 433. (A.M. 433) OPERATIONAL MATHEMATICS (3)
- 435. AXIOMATIC SET THEORY (3)
- 441. (A.M. 441) MATRIX ALGEBRA (3)
- 451. (A.M. 451) ADVANCED CALCULUS FOR ENGINEERS I: REAL VARIABLES (3)
- 452. (A.M. 452) ADVANCED CALCULUS FOR ENGINEERS II: COMPLEX ANALYSIS (3)
- 453. (Cmp.Sc. 453) NUMERICAL COMPUTATIONS (3)
- 454. (Cmp.Sc. 454) MATRIX COMPUTATIONS (3)
- 456. COMPUTABILITY AND UNSOLVABILITY (3)
- 461. (A.M. 461, Phys. 461) THEORETICAL MECHANICS (3)
- 465. CLASSICAL ANALYSIS I (3)
- 466. CLASSICAL ANALYSIS II (3)
- 470-471. ALGEBRA FOR TEACHERS (3 each)
- 472. FOUNDATIONS OF GEOMETRY (3)
- 480. BASIC ABSTRACT ALGEBRA (3)
- 481. LINEAR ALGEBRA (3)
- 484. LINEAR PROGRAMS AND RELATED PROBLEMS (3)
- 489. MATHEMATICS SEMINAR (1-6)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501-502. THEORY OF FUNCTIONS OF A REAL VARIABLE (3 each) Sets, metric spaces, measure and integration, L_p spaces and other function spaces, differentiation. Prerequisite: Math. 421.
504. (A.M. 504) OPTIMIZATION THEORY (3) Least squares problems, min-max game theory, global theory of constrained optimization, iterative methods of optimization. Prerequisite: Math. 420.
505. (A.M. 505) INTEGRAL EQUATIONS (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. (A.M.) 431 or 432 or Math. 420.
506. (A.M. 506) DISTRIBUTIONS AND GENERALIZED FUNCTIONS (3) Schwartz-Sobolev theory of distributions, tempered distributions, Fourier transforms, fundamental solutions of ordinary and partial differential equations; applications. Prerequisite: Math. (A.M.) 431 or 432 or Math. 420.
507. (A.M. 507) CALCULUS OF VARIATIONS AND OPTIMAL CONTROL (3) Classical and modern theory of the calculus of variations; problems in optimal control. Prerequisite: Math. (A.M.) 431 or 432 or Math. 420.
- 508-509. COMPLEX ANALYSIS (3 each) Analytic and meromorphic functions; Riemann's mapping theorem. Prerequisite: Math. 421.
511. LINEAR ALGEBRA (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisite: Math. 481 or 537.
515. (A.M. 515) PARTIAL DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: Math. (A.M.) 431 or 432.
516. (A.M. 516) ADVANCED PARTIAL DIFFERENTIAL EQUATIONS (3) Elliptic operators, fundamental solutions, weak and strong derivatives, Sobolev inequalities, Dirichlet problem, equations of evolution, semi-groups. Prerequisites: Math. (A.M.) 515.
- 517-518. (Stat. 517-518) PROBABILITY THEORY (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.
520. PROJECTIVE GEOMETRY (3) General study of the subject from the synthetic and analytic standpoint. Prerequisites: Math. 472, 480.
521. ANALYTIC NUMBER THEORY I (3) Improvements of the prime number theorem, L -functions and class numbers, asymptotic and arithmetic properties of coefficients of modular forms. Prerequisites: Math. 508, 594.
522. ANALYTIC NUMBER THEORY II (3) Distribution of primes, analytic number theory in algebraic number fields, transcendental numbers, advanced theory of partitions. Prerequisite: Math. 521.
523. DIFFERENTIAL GEOMETRY (3) Manifolds-differentiable structures, tangent spaces, connections, structural equations, Riemannian geometry. Prerequisite: Math. 429.
524. ADVANCED COMPLEX ANALYSIS (3) Topics include boundary behavior of analytic functions, bounded analytic functions, conformal mapping, theory of Riemann surfaces. Prerequisite: Math. 509.
525. THEORY OF FUNCTIONS OF SEVERAL COMPLEX VARIABLES (3-6) Topics include fundamental properties of holomorphic functions, complex analytic manifolds, integral representations, Cousin problems. Prerequisite: Math. 509.
526. THEORY OF SHEAVES (3) Presheaves over topological spaces; defining sheaves two ways; Čech cohomology of presheaves; cohomology of sheaves; flasks; Lubkin's punctual cochains. Prerequisites: Math. 429; Math. 480 or 535.
527. ALGEBRAIC GEOMETRY (3) Preschemes and proschemes; products; projective finite and affine presentation maps; projective quasicohherent sheaves; cohomology of quasicohherent sheaves over affine schemes. Prerequisite: Math. 526.
528. UNIFORM SPACES AND FUNCTION SPACES (3) Uniform spaces, completion, compactifications, function spaces, metrization. Prerequisite: Math. 429.

- 529-530-531. **TOPOLOGY (3 each)** Topological, product, compact, metric, and connected spaces; continuous functions; separation axioms, countability conditions, combinatory topology.
532. **THEORY OF SETS (3)** Formal development of set theory on a logical basis and related methodological problems; applications to the foundations of mathematics. Prerequisite: Math. 554 (Phil. 554); Math. 556.
533. **ADVANCED SET THEORY (3)** The constructible universe, forcing, trees, infinitary combinatorics, large cardinals; applications to topology, measure theory, and projective set theory. Prerequisite: Math. 532.
- 535-536-537. **ALGEBRA (3 each)** Basic theory of semigroups and groups, rings and modules, fields, lattices.
538. **COMMUTATIVE ALGEBRA (3)** Topics selected from noetherian rings and modules, primary decompositions, Dedekind domains and ideal theory, other special types of commutative rings or fields. Prerequisite: Math. 536.
539. **RINGS (3)** Selected topics from the theory of rings. Prerequisite: Math. 536.
542. (Stat. 542) **STATISTICAL DISTRIBUTION THEORY IN SCIENTIFIC WORK: I. DISCRETE MODELS (3)** Statistical distributions arising in scientific modeling and statistical inference; structures, interrelations, characterizations, and simulation with practical examples. Prerequisite: Math. (Stat.) 410; knowledge of matrix algebra.
543. (Stat. 543) **STATISTICAL DISTRIBUTION THEORY IN SCIENTIFIC WORK: II. CONTINUOUS MODELS (3)** Statistical distributions arising in scientific modeling and statistical inference; structures, interrelations, characterizations, and simulation with practical examples. Prerequisite: Math. (Stat.) 542.
- 547-548-549. **LIE THEORY (2 each)** Topics selected from theory of topological semigroups, topological groups, lie groups, transformation groups. Prerequisite: Math. 531.
551. (Cmp.Sc. 551) **NUMERICAL ALGEBRA (3)** Zeros of polynomials; iterative solution of linear and nonlinear systems; sparse matrix techniques; eigenvalues and eigenvectors. Prerequisite: Cmp.Sc. 454 or Math. 441.
552. (Cmp.Sc. 552) **INTRODUCTION TO APPROXIMATION THEORY (3)** Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420 and 3 credits in computer science.
553. (Cmp.Sc. 553) **NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS (3)** Methods for initial value and boundary value problems. Stability and convergence analysis, automatic error control, and stiff systems. Prerequisites: Cmp.Sc. 453, Math. 431.
554. (Phil. 554) **LOGIC AND METAMATHEMATICS (3)** Completeness, Lowenheim-Skolem and compactness theorems. First-order arithmetic, recursiveness and the incompleteness and consistency of arithmetic. Prerequisite: Math. 428.
555. **ADVANCED RECURSION THEORY (3)** Recursively enumerable sets, degrees of unsolvability, admissible ordinals, inductive definitions, projective hierarchy, fine structure of the constructible hierarchy. Prerequisite: Cmp.Sc. 559 or Math. 556.
556. **RECURSION THEORY (3)** Recursive functions; normal form, enumeration and separation theorems; partial recursive functions; recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Math. 554 (Phil. 554).
557. **MODEL THEORY (3)** Countable models, saturated models, categorical theories and related topics. Prerequisites: Math. 532, 556.
559. (Stat. 559) **THEORY OF STOCHASTIC PROCESSES (3)** Stationary, independent, and orthogonal processes; discrete and continuous Markov processes; martingales and semi-martingales applications. Prerequisite: Math. 518.

- 560-561. (A.M. 560-561) ORDINARY DIFFERENTIAL EQUATIONS (3 each) Linear spaces and operators, existence and uniqueness of solutions, linear systems, Green's functions, eigenvalue problems—including Fourier series. Prerequisite: Math. 72 or 250 or 383 or Math. (A.M.) 431.
562. THEORY OF SPECIAL FUNCTIONS (3) Topics include asymptotic expansions; Riemann-Papperitz and Trusdell's F equations; orthogonal polynomials; generating, beta, zeta, hypergeometric, Bessel, Legendre, elliptic functions. Prerequisites: Math. 72 or 250 or 383 and either Math. 420 and 452, or Math. 508.
563. APPROXIMATION THEORY (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds; degree of approximation; approximation of linear functionals. Prerequisites: Math. 453, 501.
564. (Cmp.Sc. 564) NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS (3) Methods of parabolic, hyperbolic, and elliptic partial differential equations; finite difference and variational methods; splines, finite elements. Prerequisites: Cmp.Sc. 453, 454; A.M. 451 or Math. 405.
565. FUNCTIONAL ANALYSIS (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 502.
566. ALGEBRAIC NUMBER THEORY I (3) Dedekind rings; cyclotomic and Kummer extensions; valuations; ramification, decomposition, inertial groups; Galois extensions; locally compact groups of number theory. Prerequisites: Math. 537, 594.
567. ALGEBRAIC NUMBER THEORY II (3) Local and global class field theory; integral quadratic forms; algebraic and arithmetic groups; algebraic function of one variable. Prerequisite: Math. 566.
568. ADVANCED ALGEBRA I (3) Noetherian and Artinian modules and rings, simple and semi-simple modules and rings, radicals. Prerequisite: Math. 537.
569. ADVANCED ALGEBRA II (3) Multilinear algebra, commutative algebra, homological algebra. Prerequisite: Math. 568.
570. SPECIAL TOPICS IN GEOMETRY (3-12)
571. SPECIAL TOPICS IN ANALYSIS (3-12)
572. SPECIAL TOPICS IN ALGEBRA (3-12)
573. SPECIAL TOPICS IN APPLIED MATHEMATICS (3-12)
574. SPECIAL TOPICS IN FOUNDATIONS OF MATHEMATICS (3-12)
- 575-576. MATHEMATICS SEMINAR (1-6 each) Selected topics from recent mathematical developments.
578. SPECIAL TOPICS IN TOPOLOGY (3-12)
579. (Cmp.Sc. 579) SPECIAL TOPICS IN NUMERICAL ANALYSIS (2- 12)
580. SPECIAL TOPICS IN NUMBER THEORY (2-12)
- 581-582. GROUP THEORY I, II (3 each) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 535.
583. HOMOLOGICAL ALGEBRA (3) Modules, diagrams, functors, homology of complexes, resolutions, cohomology of groups, tensor and torsion products. Prerequisite: Math. 536.
- 584-585-586. ALGEBRAIC TOPOLOGY (2 each) Development of singular and Čech homology and cohomology theories; homotopy and cohomotopy theories. Prerequisite: Math. 531.
590. COLLOQUIUM (1-3)
- 592-593-594. NUMBER THEORY (3 each) Congruences, quadratic residues, arithmetical functions, Dirichlet's theorem, prime number theorem, classical multiplicative ideal theory, partitions, valuations and p-adic numbers, divisors. Prerequisite: Math. 480. Prerequisite or concurrent: Math. 508.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2)

NOTE: *Courses in Applied Mathematics, Computer Science, and Statistics are listed separately.*

MATHEMATICS (MATH)

HELMUT E. WEBER, *In Charge of the Graduate Program in Mathematics*
Radnor Center, 259 Radnor-Chester Road, Radnor, PA 19087

Degree Conferred: M.Ed.

Graduate Faculty: Associate Members Callahan, Duncan, and Llorens.

The program is offered specifically to permit teachers in the area to pursue advanced studies through evening classes while employed in teaching. Courses offered for the program are established and controlled by the resident departments at the University Park Campus.

Credit requirements may be satisfied by completing a minimum of 18 credits in approved mathematics courses, a minimum of 6 credits in approved mathematics and science courses, and a minimum of 6 credits in approved education courses. In addition, a term paper is required. All requirements must be met within six years or seven consecutive summers.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. An applicant must have a bachelor's degree and have completed 27 credits in mathematics including at least 15 credits at the intermediate level beyond calculus. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details concerning this program may be obtained by writing directly to the Radnor Center for Graduate Studies.

MECHANICAL ENGINEERING (M E)

DONALD R. OLSON, *Head of the Department*
207 Mechanical Engineering Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Brickman, Cunningham, Faeth, Heinsohn, Henderson, Henry, Kuo, Lestz, Olson, Park, Reethof, Schmidt, Shearer, Wambold, Weber, and Wolgemuth.

Graduate Faculty: Associate Members Hayhoe, Midha, Parke, Webb, and Williams.

Graduate programs and research facilities are available in thermodynamics and combustion, heat transfer, fluid mechanics, dynamic system analysis, mechanical design, biomedical engineering, and energy systems. Air pollution control, automotive safety, designing for noise control and for reliability also provide many research and design opportunities.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an in-depth study of one foreign language (6 credits), by taking two or more courses (minimum of 6 credits) of a nontechnical nature in a single area of study appropriate and related to the student's career orientation, or by taking an advanced technical writing course (Engl. 418 — 4 credits) and presenting a formal proposal for thesis research (M.E. 580 — 2 credits) to the doctoral committee.

A student working toward an M.S. degree may choose one of the following options: (1) a minimum of 24 course credits plus 6 thesis credits (M.E. 600) culminating in the submission of a thesis to the Graduate School, (2) a minimum of 30 course credits plus a technical report, or (3) a minimum of 30

course credits plus submission of a Ph.D. thesis research proposal, provided the student has passed the candidacy examination.

The entering student must hold a bachelor's degree in engineering or physical science. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MECHANICAL ENGINEERING (M E)

- 400. HONORS THESIS (1-3)
- 401. MECHANICAL ENGINEERING (3-12)
- 403. ROCKET PROPULSION (3)
- 405. AIR POLLUTION CONTROL SYSTEMS (3)
- 409. GAS TURBINES (3)
- 410. POWER PLANTS (3)
- 411. REFRIGERATION AND AIR CONDITIONING (3)
- 412. HEAT TRANSFER (3)
- 413. INTERNAL COMBUSTION ENGINES (3)
- 414. ENGINEERING ANALYSIS OF THERMAL SYSTEMS (3)
- 415. ENGINEERING ANALYSIS FOR MECHANICAL DESIGN (3)
- 417. THEORY OF ENGINEERING INSTRUMENTS (3)
- 418. PRINCIPLES OF TURBOMACHINERY (3)
- 420. HEAT-EXCHANGER DESIGN (3)
- 421. (Aersp. 421) INTERMEDIATE VISCOUS FLOW (3)
- 450. DESIGN OF MACHINE TOOLS (3)
- 451. ADVANCED MACHINE DESIGN PROBLEMS (3)
- 452. DESIGN ANALYSIS (3)
- 454. ADVANCED MACHINE DYNAMICS (3)
- 455. AUTOMATIC CONTROL SYSTEMS (3)
- 458. NOISE CONTROL IN MACHINERY (3)
- 460. RELIABILITY CONCEPTS IN DESIGN (3)
- 470. FUNDAMENTALS OF AIR POLLUTION (3)
- 472. ENGINEERING AND ADMINISTRATION OF AIR POLLUTION CONTROL (8)

- 503. THERMODYNAMIC PROCESS ANALYSIS (3) Development of equations governing separate processes in complete machines to give basic system parameters and characteristics; transient processes; irreversible effects.
- 504. ADVANCED ENGINEERING THERMODYNAMICS (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject.
- 505. DESIGN OF AIR POLLUTION CONTROL SYSTEMS (3) Advanced principles of design drawn from professional literature, including mechanical collectors, electrostatic precipitators, filters, scrubbers, and industrial ventilation systems. Prerequisite: M.E. 405.
- 506. SELECTED TOPICS IN MECHANICAL ENGINEERING (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.
- 512. HEAT TRANSFER — CONDUCTION (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions.
- 513. HEAT TRANSFER — CONVECTION (3) Laminar and turbulent flow heat transfer in natural and forced convection systems.
- 514. HEAT TRANSFER — RADIATION (3) Thermal radiation fundamentals; specular and diffuse systems; differential and integral methods; numerical techniques; industrial applications.
- 515. TWO-PHASE HEAT TRANSFER (3) Heat transfer processes involving evaporation, boiling, and condensation.

516. **COMBUSTION IN PROPULSION SYSTEMS (3)** Theoretical formulations and methods of solution of engineering problems and physical processes in chemical propulsion systems.
519. **COMPRESSIBLE FLUID FLOW (2-4)** Two-dimensional subsonic flow; similarity rules; theory of characteristics; supersonic and hypersonic flows; nonsteady flow; oblique shock waves.
521. **ELECTROMAGNETIC AND THERMODYNAMIC FLOW SYSTEMS (3)** Thermodynamic equations for flow of reacting and nonreacting fluids in electromagnetic fields; applications to engineering problems.
522. **BOUNDARY LAYER AND SEPARATED FLOWS (3)** Behavior of viscous fluids, with emphasis on boundary layer and separation effects in internal flow.
540. **NUMERICAL SOLUTIONS APPLIED TO HEAT TRANSFER AND FLUID MECHANICS PROBLEMS (3)** Application of finite difference methods to the study of potential and viscous flows and conduction and convection heat transfer.
552. **ADVANCED DYNAMICS OF MACHINES (3-6)** Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.
555. **AUTOMATIC CONTROL SYSTEMS (3)** Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.
557. **MECHANISM SYNTHESIS (3)** Geometrical and algebraic methods for synthesizing planar and spatial mechanisms, dynamics of spatial mechanism.
558. **FLUID CONTROL SYSTEMS (2)** Modeling fluid system dynamic performance, experimental determination of the actual behavior, and comparison of predicted behavior with actual behavior. Prerequisite: M.E. 455.
562. **SIMULATION OF MECHANICAL SYSTEMS (3)** Introduces computational fundamentals, including digital logic; programming language, basic numerical analysis and data processing, as applied to mechanical simulation techniques. Prerequisites: M.E. 54, 66.
571. **AIR POLLUTION SEMINARS (1-2)** Weekly seminars featuring the contributions of many different disciplines to the solution of air pollution and other environmental problems.
580. **INVESTIGATION PROJECTS (1-6)** Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

METALLURGY (METAL)

HOWARD W. PICKERING, *In Charge of Graduate Programs in Metallurgy*
209 Steidle Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bitler, Hoke, Muan, Pickering, Ryba, Simkovich, and Thrower.

Graduate Faculty: Associate Members Macmillan and Osseo-Asare.

This program is one of the options in which a graduate student in the Department of Materials Science and Engineering can receive an advanced degree. A student may specialize, through both course work and research, in the science and engineering aspects of chemical, physical, or mechanical metallurgy.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language together with courses from other designated areas.

Suitable preparation for graduate study in this program may be found in one of the material sciences such as ceramic science, fuel science, metallurgy, or solid state science; in engineering fields such as chemical or mechanical engineering; in basic physical sciences such as chemistry or physics; or in earth sciences such as geochemistry and mineralogy. Students with a 2.50 junior-senior average and with ap-

appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METALLURGY (METAL)

- 401. METALLURGICAL PROCESSES AND KINETICS (3)
 - 402. CORROSION ENGINEERING (3)
 - 403. PHYSICAL METALLURGY LABORATORY (1)
 - 404. DESIGN OF PYROMETALLURGICAL SYSTEMS (3)
 - 405. PHYSICAL METALLURGY (3)
 - 406. ALLOY SYSTEMS (3)
 - 407. SOLIDIFICATION PROCESSING (3)
 - 408. DEFORMATIONAL PROCESSING (3)
 - 410. METALLURGICAL INVESTIGATIONS AND DESIGN (1-6)
 - 412. SOLID STATE METALLURGY (3)
 - 414. EXTRACTIVE METALLURGY LABORATORY (1)
 - 416. HYDROMETALLURGY LABORATORY (1)
 - 426. (Mn.Pr. 426) HYDROMETALLURGY (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
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- 501. METALLURGICAL PROBLEMS (1-6 per term) Independent study of special problems in metallurgy.
 - 505. OXIDATION OF METALS (3) The course will cover high-temperature oxidation of metals and alloys including Wagner's theories of internal oxidation. Prerequisite: Chem. 451.
 - 507. (Mn.Pr. 507) HYDROMETALLURGICAL PROCESSING (3) Fundamental physico-chemical factors underlying the aqueous extraction and recovery of metals and non-metals from ores, minerals, and scrap metal. Prerequisite: Metal (Mn.Pr.) 426.
 - 508. KINETICS OF PHASE TRANSFORMATIONS (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates: *Bitler*
 - 509. INTRODUCTORY THEORETICAL PHYSICAL METALLURGY (3) Quantum mechanics and its application to solid-state theory; introduction of Schroedinger's equation, its solutions, free-electron model, band model. *Bitler*
 - 510. MAGNETIC AND TRANSPORT PROPERTIES OF MATERIALS (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: Metal. 509. *Bitler*
 - 513. ADVANCED CHEMICAL METALLURGY I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites : Chem. 452, Metal. 301, 402, 404. *Simkovich*
 - 514. DISLOCATION THEORY (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Bitler*
 - 515. CORROSION OF METALS (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments. *Pickering*
 - 516. FLOW AND FRACTURE OF SOLIDS (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisite: Metal. 514. *Macmillan*
 - 518. HETEROGENEOUS EQUILIBRIA AT HIGH TEMPERATURES (2-3) Treatment of high-temperature equilibria in metal and oxide systems involving crystalline, liquid, and gas phases. Prerequisite: Metal. 513. *Muan*

519. **ADVANCED CHEMICAL METALLURGY II (3)** Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: Metal. 513.

520. **FOUNDRY METALLURGY (3)** Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisite: Metal. 513.

522. **SOLID-PHASE REACTIONS IN METALS (3)** Mechanisms and rate-determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisite: Metal. 508. *Bitler*

535. (E.Mch. 535) **CRYSTAL DEFECTS AND MECHANICAL RESPONSE (3)** Mechanical responses of crystalline solids containing point, line, and interfacial defects; elastic and plastic responses. Prerequisite: Metal. 514 or E.Mch. 414.

NOTE: Courses in introductory thermodynamics and kinetics of metals, and the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Materials Science.

METEOROLOGY (METEO)

ALFRED K. BLACKADAR, *Head of the Department*
503 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthes, Blackadar, Cahir, R. de Pena, Dutton, Fraser, Hosler, Panofsky, and Thomson.

Graduate Faculty: Associate Members Albrecht, Clark, Olivero, and J. Pena.

Candidates may specialize in the study of problems in either theoretical or applied meteorology including such areas as cloud physics, various phases of dynamic meteorology and geophysical fluid dynamics including turbulence and atmospheric circulation, numerical modeling, macro- and microclimatology, synoptic meteorology, or meteorological instrumentation. The department also encourages interdisciplinary studies in such fields as agricultural meteorology, biometeorology, water resources, air pollution, and fluid mechanics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of German or Russian. The thesis or paper option is available for the M.S. degree.

Requirements for admission include mathematics through differential equations and one year of college physics. Undergraduate study of meteorology is not required for admission. Special programs are available to encourage the graduate study of meteorology by all students with strong backgrounds in mathematics, physics, or engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METEOROLOGY (METEO)

400. **METEOROLOGY FOR TEACHERS (3)**

401. **PHYSICAL CLIMATOLOGY FOR TEACHERS (3)**

404. **MOTIONS OF THE ATMOSPHERE AND OCEANS (3)**

407. **ELEMENTS OF PHYSICAL OCEANOGRAPHY (3)**

411. **INTRODUCTION TO SYNOPTIC METEOROLOGY (3)**

418. **INTRODUCTORY PHYSICS OF THE UPPER ATMOSPHERE (3)**

420. **TROPICAL METEOROLOGY (3)**

430. **INTRODUCTION TO SYNOPTIC METEOROLOGY LABORATORY (3)**

431. SYNOPTIC METEOROLOGY LABORATORY I (3)
 432. SYNOPTIC METEOROLOGY LABORATORY II (2-10)
 433. ADVANCED SYNOPTIC ANALYTICAL TECHNIQUES (3)
 434. APPLICATION OF METEOROLOGICAL SATELLITE DATA TO ANALYSIS AND FORECASTING (3)
 442. OBSERVING METEOROLOGICAL PHENOMENA (3)
 443. PHYSICAL METEOROLOGY (3)
 446. (Geosc. 402) NATURAL DISASTERS SEMINAR (2)
 450. APPLICATIONS OF STATISTICS TO METEOROLOGY (3)
 451. INTRODUCTION TO DYNAMIC METEOROLOGY (3)
 452. HYDRODYNAMICS OF THE ATMOSPHERE (3)
 453. ATMOSPHERIC THERMODYNAMICS (3)
 461. THEORY OF METEOROLOGICAL INSTRUMENTS (3)
 472. PHYSICAL AND DYNAMIC CLIMATOLOGY (3)
 473. INTRODUCTION TO MICROMETEOROLOGY (3)
 475. CHEMISTRY OF THE ATMOSPHERE (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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502. SELECTED TOPICS OF ADVANCED METEOROLOGY (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.
 503. ATMOSPHERIC TURBULENCE (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.
 505. BIOCLIMATOLOGY (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.
 506. ADVANCED METEOROLOGICAL ANALYSIS (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.
 507. DYNAMIC OCEANOGRAPHY (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.
 508. PHYSICS OF THE UPPER ATMOSPHERE (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.
 509. THEORETICAL CLIMATOLOGY (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.
 510. CLOUD PHYSICS (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.
 520. INDIRECT ATMOSPHERIC PROBING (3) Analysis and description of measurements made with radar and bistatic radio, optical and acoustic systems used for indirect atmospheric sounding. Prerequisite: Meteo. 443.
 550. ATMOSPHERIC MOTIONS (3) Fundamental properties and conservation requirements of the hydrodynamic equations; elements of advanced dynamic meteorology and applications to atmospheric dynamics. Prerequisite or concurrent: A.M. 451.
 551. ATMOSPHERIC WAVE MOTION (2-3) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 550.
 552. NUMERICAL WEATHER PREDICTION (2-3) Finite difference and spectral methods, barotropic and baroclinic models, filtered and primitive equation models, synoptic-scale and mesoscale models. Prerequisite: Meteo. 550.
 553. ENERGETICS OF ATMOSPHERIC MOTION (2-3) Theoretical investigation of the conversions of energy in the atmosphere; maintenance of the general circulation and global thermodynamics. Prerequisite: Meteo. 550.
 555. ATMOSPHERIC DIFFUSION (2-3) Dispersion of atmospheric contaminants; experiments, theory and practical implications for air pollution problems. Prerequisite: 3 credits of statistics.

561. CHEMISTRY OF THE ATMOSPHERE (2) Fundamental knowledge of chemical characteristics of atmospheric components and transformations, in connection with cloud microphysics, circulation, and air pollution. Prerequisite: 3 credits in chemistry.

597. SPECIAL TOPICS (1-6)

NOTE: Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Materials Science.

MICROBIOLOGY (MICRB)

DANIEL R. TERSHAK, Acting Head of the Department of Microbiology and Cell Biology
S-101 Frear Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Casida, Ceglowski, Docherty, Gaffney, Lindstrom, Ludwig, Pootjes, Tershak, Zarkower, and Zimmerman.

Graduate Faculty: Associate Members McDonel, Porter, Schlegel, Stevens, and Yasbin.

Opportunities for graduate study are available in microbiology, immunology, virology, and cell biology. Among current areas of research are included such topics as bacterial ecology, genetics, and physiology; food and industrial microbiology; photosynthesis of procaryotes; chemical and pathogenic properties of both bacterial and animal viruses; viral and tumor immunology; and mammary carcinogenesis. There is opportunity for cooperative research with other departments.

The communication and foreign language requirement for the Ph.D. may be satisfied by intermediate knowledge of one foreign language (French, German, or Russian).

Prerequisites for admission are 16 credits in inorganic and organic chemistry, 6 in physics, 4 in microbiology, and mathematics through calculus. Admission may be granted with deficiencies up to 8 credits, to be made up while pursuing graduate work. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. A satisfactory score on the Graduate Record Examination is required for admission.

MICROBIOLOGY (MICRB)

- 400. INTRODUCTORY ENVIRONMENTAL MICROBIOLOGY (2)
- 401. ADVANCED BACTERIOLOGY (2)
- 408. LABORATORY INSTRUCTIONAL PRACTICE (1-2)
- 410. IMMUNOLOGY AND SEROLOGY (2)
- 411. SURVEY OF MICROBIOLOGY (1 per term)
- 412. MEDICAL MICROBIOLOGY (2)
- 413. MICROBIAL SOIL ECOLOGY (2)
- 414. FOOD MICROBIOLOGY (2-4)
- 415. INTRODUCTION TO ANIMAL VIRUSES (2)
- 416. INDUSTRIAL MICROBIOLOGY (2)
- 417. EPIDEMIOLOGY (2)
- 418. BACTERIAL VIRUSES (2)
- 421. LABORATORY OF GENERAL AND APPLIED MICROBIOLOGY (2)
- 422. PRACTICAL MEDICAL MICROBIOLOGY (2)
- 474. ADVANCED CELL BIOLOGY (2)
- 476. THE PHOTOSYNTHETIC PROCESS (3)
- 478. THE BIOLOGY OF CANCER CELLS (2)
- 496. INDEPENDENT STUDIES (1-12)

507. SEMINAR (1 per term) Reports on current fields of research.
508. BACTERIAL PHYSIOLOGY (2-4) Contributions of environment, finestructure, and metabolism to the functioning cell. Prerequisite: 6 credits of biochemistry.
510. ADVANCED IMMUNOLOGY (2) Discussions of the modern concepts in immunology. Emphasis on areas of current interest. Prerequisites: Micrb. 410, 6 credits in biochemistry.
512. MICROBIOLOGICAL METHODS (1-6) Practice in special laboratory techniques of modern microbiology.
516. BACTERIAL GENETICS (2-4) Mechanisms of variation in microorganisms including mutation, adaptation, sexual recombination, transduction, and transforming factors. Prerequisites: 3 credits each in microbiology and genetics.
520. BIOCHEMICAL VIROLOGY (2) Role of enzymes and nucleic acids in virus synthesis. Regulation of virus reproduction in animal and bacterial cells. Prerequisite: 6 credits of biochemistry.
529. (C.E. 579) AQUATIC MICROBIOLOGY (3) Ecology and physiology of microorganisms of inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

MICROBIOLOGY (MICRO)

FRED RAPP, *Chairman of the Department*
The Milton S. Hershey Medical Center
Hershey, PA 17033

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bartlett, Geder, Hyman, Kreider, Rapp, Taylor, M. Tevethia, and S. Tevethia.

Graduate Faculty: Associate Members Howett, Isom, Lipton, Marquez, St. Jeor, and Tenser.

This program is oriented to the study of the general areas of bacteriology, virology, and immunology. Active research programs exist in a variety of subdivisions of these disciplines. Some areas emphasized include the replication and structure of viral nucleic acids, the role of viruses in tumor formation, viral latency in mammalian systems, tumor immunology, electron microscopy of viruses and virus-infected cells, and eucaryotic gene regulation.

The communication and foreign language requirement may be satisfied by demonstrating competence in one foreign language, such as French, German, or Russian. Alternatively, with special permission, courses which enhance communication skills can be substituted for the foreign language requirement.

Qualified students with undergraduate preparation in either the biological, biochemical, or physical sciences may apply. An adequate background in biology, chemistry, and mathematics and an overall grade-point average of 3.00 or better are required.

The best-qualified applicants will be accepted on a space-available basis. Formal applications should contain two letters of recommendation and a brief personal essay summarizing the background and professional goals of the applicant. Graduate Record Examination scores are required.

This program is offered only at The Milton S. Hershey Medical Center.

MICROBIOLOGY (MICRB)

551. MEDICAL MICROBIOLOGY (3) Principles of medical microbiology: bacterial structure and function, host-parasite relationships, and bacteria, fungi, and viruses causing human disease.
552. MEDICAL MICROBIOLOGY LABORATORY (1) Laboratory exercises to augment Micrb. 551. Laboratory tests used to characterize microorganisms and to aid in diagnosis of disease. Concurrent: Micrb. 551.

- 553. SCIENCE OF VIROLOGY (3) Replication of viruses and effect on host, including transfer of genetic information, immunology, and oncogenic properties of viruses.
- 554. PRINCIPLES OF IMMUNOLOGY (2) Study of immune response. Nature of antigens, structure, function of antibodies, hypersensitivity, transplantation and tumor immunology, autoimmunity, and immunosuppression.
- 555. MICROBIAL PHYSIOLOGY AND METABOLISM (3) Physiology and comparative biochemistry of microorganisms, especially human pathogens. Regulatory mechanisms, energy metabolism, and other topics essential for cell replication.
- 556. MOLECULAR GENETICS (3) Structure, synthesis, and function of DNA, RNA, and proteins. Emphasis on gene structure and function in the eucaryotic cell.
- 557. ELECTRON MICROSCOPY (3) The application of electron microscopy to microbiology, including specimen preparation, use of the electron microscope, and photography. Prerequisites: admission to the medical or graduate program and permission of instructor.
- 558. MEDICAL PARASITOLOGY (2) Basic information on protozoa, helminths, arthropods, and mollusks involved in the causation of human diseases.
- 559. EPIDEMIOLOGY (2) Provides information on epidemiology—the study of factors that affect occurrence and course of disease in a population.
- 572. LITERATURE REPORTS (1 per term) Weekly analysis of current literature in microbiology.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

MINERAL ECONOMICS (MN EC)

RICHARD L. GORDON, *In Charge of Graduate Programs in Mineral Economics*
221 Walker Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Gordon, Schenck, Tilton, and Vogely.

Graduate Faculty: Associate Member Sani.

The program in mineral economics prepares students for careers in mineral industries management, administration, or economic analysis and planning. Students may specialize in such areas as commodity analysis (energy, metals, or nonmetals); resource economics (mineral policy or area studies); industrial economics (administration, market research, or financial matters); geostatistical and economic analysis of exploration and exploitation problems; or operations research and statistics (resource allocation, forecasting, or decision making).

Two related, but distinctly different, general programs for obtaining the M.S. and Ph.D. degrees are available, the one chosen depending on the education and practical experience of the candidate. One program is for students whose background is in the mineral industries and who wish to combine their scientific training with an understanding in depth of the methods by which economics can aid in solving problems in mineral industries exploration, exploitation, and processing. Requirements for admission to this program are 24 credits in chemistry, physics, mathematics, or statistics; 12 in the earth sciences; 9 in economics, mineral economics, commerce, business administration, or industrial management; and 6 in engineering subjects.

The second program is for students whose background is in economics and whose training and experience have given them an interest in applying their economic skills to the solution of mineral industries problems. Requirements for admission to this program are 12 credits in economics, mineral economics, and business administration; 6 in geological sciences; and 9 in mathematics and statistics.

The differences between the programs followed by these two groups of students will affect many aspects of their graduate programs — thesis work, required mineral economics courses, and elective selection. In all cases, the choices among courses and the emphasis within courses taken would be determined by the background of the student. The mineral-industries-based program places equal emphasis on the technical and economic aspects of mineral economics, and the economics-based program places more emphasis on the economic than on the technical features of the problems considered.

In addition to the normal degree requirements of the Graduate School, candidates for the M.S. degree must write a thesis and defend it orally. Doctoral candidates in the mineral-industries-based program must complete at least 15 credits in economics (including courses used for admission). M.S. students in both programs are also required to take 9-12 credits in statistics and computer science either before admission or as courses taken in addition to the minimum required for the M.S. degree. Doctoral candidates in the economics-based program must complete at least 12 credits in the earth sciences or mineral engineering. The candidacy examination for the doctorate is oral, and the oral examination for the M.S. degree at The Pennsylvania State University may be used as the candidacy examination for the doctorate. If this is done, the M.S. examination will be more detailed and broader in scope than it would be for the M.S. alone. The comprehensive examination for the doctorate includes written examinations in the major program and minor fields in addition to the oral examination required by the Graduate School. The communication requirement is satisfied by departmentally approved courses in mathematical statistics and mathematics. There is no foreign language requirement.

Students with deficiencies of 9 credits or fewer in either program may be admitted as degree candidates but will be required to make up such deficiencies without these credits being applicable toward the advanced degree. Students with a 2.75 junior-senior average, above-average scores on the Graduate Record Examination Aptitude Test, and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

MINERAL ECONOMICS (MN EC)

- 453. NONMETALLIC MINERALS (3)
- 483. ECONOMICS OF THE METALS INDUSTRIES (3)
- 484. POLITICAL ECONOMY OF ENERGY AND THE ENVIRONMENT (3)
- 490. MINERAL VALUATION (3)
- 495. MINERAL INDUSTRIES DECISION MAKING (3)
- 500. ADVANCED READINGS IN MINERAL ECONOMICS (3) Selected readings on topics in mineral history, mineral economics research, applications of economic theory, mineral policy and law, and mineral exploration.
- 504. ADVANCED PRINCIPLES OF MINERAL ECONOMICS (3) Minerals as capital — taxation, conservation, and land tenure; operations of mineral markets; government policy; minerals in world trade and development.
- 506. ADVANCED STUDIES IN MINERAL COMMODITIES (3) Economic studies of selected mineral commodities and their products.
- 509. (Geol. 509) GEOLOGY AND ECONOMICS OF THE CONSTRUCTION MATERIALS (3) Occurrence, origin, and marketing of the mineral materials used by the construction industry. Economic and geologic evaluation of actual deposits.
- 510. (Geol. 510) GEOLOGY AND ECONOMICS OF THE INDUSTRIAL MATERIALS (3) Occurrence, origin, and marketing of the industrial minerals and evaluation of deposits. Chemical and ceramic raw materials emphasized.
- 513. APPRAISAL OF MINERAL RESOURCES AND ANALYSIS OF EXPLORATION DECISIONS (3) Mineral resource concepts; various quantitative methods for resource evaluation, including computer simulation; exploration economics and decision making within quantitative frameworks. Prerequisite: Mn.Ec. 490.

519. (Econ. 519) **MINERAL POLICY ANALYSIS (3)** Principles of policy analysis; cost-benefit and other analytical techniques; environmental analyses; case studies of legislative and administrative mineral policy issues.

524. **THE ECONOMIC ANALYSIS OF ENERGY MARKETS (3)** Unified theory of exploration, development, and production; its application; domestic and foreign public policies; new sources; forecasting. Prerequisite: Econ. 302.

529. **MINERAL INVESTMENT VALUATION (3)** Investment analysis for mineral properties; including reserve estimation, capital budgeting techniques under risk, taxation, capital cost, and selected investment decisions.

530. **CONTEMPORARY ISSUES IN MINERAL FINANCE (3)** Critical investigation of current problems in mineral finance, including the issues of capital availability, and domestic and foreign mineral investment. Prerequisite: Mn.Ec. 490 or Fin. 405.

590. **COLLOQUIUM (1-3)**

593. **TECHNICAL PROBLEMS IN MINERAL ECONOMICS (1-12)** Individual research involving library, laboratory, or field work designed to provide solutions to a selected technoeconomic problem in mineral industries. Prerequisites: Mn.Ec. 500, 504.

MINERAL ENGINEERING MANAGEMENT (M E M)

R. V. RAMANI, *Section Chairman of Mineral Engineering Management*
104 Mineral Sciences

Degree Conferred: M.Eng.

Graduate Faculty: Senior Members Aplan, Farouq Ali, Given, Hummel, Lovell, Manula, W. Miller, Niebel, Ramani, Rosenshine, Saperstein, Schenck, Stahl, and Stefanko.

Graduate Faculty: Associate Members Guild and Morley.

This program is designed to educate engineers for advancement into executive production management positions in the mineral and heavy construction industries, in development and sales in manufacturing companies, and in consulting firms. Its aim is to provide the knowledge, skills, and attitudes needed by persons to become innovators and responsible decision-making leaders. Participants are trained to create new designs, systems, and methods, and to plan, develop, and lead mineral industry organizations.

The content of appropriate courses is based upon specific problems encountered in the mineral industries. Such courses are offered by the departments which have combined their resources to offer this interdisciplinary effort: the Departments of Mineral Engineering (Mining and Petroleum and Natural Gas sections), Mineral Economics, Materials Science and Engineering, and Industrial and Management Systems Engineering. Courses in these areas and others may be selected by students and adapted to their individual interests.

The program emphasizes quantitative methods, principles of economics applied in mineral industries, and management.

Students are required to present a scholarly written report on a suitable project, the topic of which may be suggested by industry.

For admission a bachelor's degree in one of six engineering branches of mineral industry (mining, petroleum, mineral processing, metallurgy, fuel, and ceramics) or some other closely related field (industrial, civil, geological, mechanical, or chemical engineering) is required. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MINERAL ENGINEERING MANAGEMENT (M E M)

510. **PRODUCTION AND OPERATIONS MANAGEMENT (3-9)** Overall planning, design, and selection of equipment; programming and scheduling of mineral operations; statistical control of costs and production indices.

MINERAL PROCESSING (MN PR)

LEONARD G. AUSTIN, *In Charge of Graduate Programs in Mineral Processing*
108 Steidle Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aplan, Austin, Hogg, and Lovell.

Graduate Faculty: Associate Members Luckie and Osseo-Asare.

This program is one of the options in which a graduate student in the Department of Mineral Engineering can receive an advanced degree. After ores and minerals are mined, they are usually processed to concentrate valuable components or remove undesirable components; then they are converted into useful products. The process engineering involves large plants which treat millions of tons of material per year at low cost, and is essential to such important industries as coal, power generation, steel, nonferrous metals, heavy chemicals, cement, and nonmetallic minerals. The world is facing shortages of energy, water, and raw materials, and the mineral processing engineering profession will play a key role in reducing and solving these problems. Increased efficiency and new ideas are urgently needed.

The training of a mineral processing engineer involves interdisciplinary combinations of chemistry, physics, the geological sciences, and engineering. This knowledge is then integrated with specialized knowledge — the creation, characterization, separation, agglomeration, and handling of mineral particles; the flotation and surface chemistry of mineral particles; and chemical extractions and separations — to provide the basis for developing and understanding the practical means of removal of valuable material from the rock body.

Pollution control is an important aspect of mineral processing because of the problems of disposal of large quantities of waste produced by the mining, metallurgical, cement, power, and heavy chemical industries, and the volume of process water used by these industries. Many air and water pollution control methods use equipment and processes originally developed for minerals treatment. Mineral processing methods are involved in the recycling and reuse of metals and other materials. A student may emphasize pollution control through course work and thesis research. The section also cooperates in the all-University interdisciplinary program leading to the Master of Science in environmental pollution control or the Master of Environmental Pollution Control.

The program of study for each student is decided by a study panel consisting of three faculty members and the student. The communication and foreign language requirement for the Ph.D. degree may be satisfied by reading proficiency in one foreign language. Students whose first language is English must demonstrate proficiency in German, Russian, or Japanese (or other language in which a major body of relevant technical literature exists). Students whose first language is not English will be required to show fluency in reading, speaking, comprehending, and writing English and may in some cases be required to demonstrate proficiency in one other approved language.

Graduates with bachelor's degrees in engineering, chemistry, chemical engineering, materials (ceramics, metallurgy), fuels, geological sciences, mathematics, mining, or physics are eligible for admission. Students with deficiencies may be required to make them up concurrently with their graduate studies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds (such as industrial experience), abilities, and interests.

The following courses listed elsewhere are appropriate for Mineral Processing students: Mat.Sc. 411, 420; Metal. 401, 404, 414.

MINERAL PROCESSING (MN PR)

- 401. MINERAL PROCESS ENGINEERING (3)
- 413. MINERAL PROCESSING LABORATORY (1)
- 421. PARTICLE TECHNOLOGY LABORATORY (1-3)
- 424. COAL PREPARATION (3)
- 425. INTERFACIAL PHENOMENON AND FLOTATION (3)
- 426. (Metal. 426) HYDROMETALLURGY (3)
- 427. POLLUTION CONTROL IN THE MINERAL PROCESS INDUSTRIES (3)

- 501. INTERFACIAL PHENOMENA IN MINERAL SYSTEMS (3) Applications of surface phenomena to mineral engineering systems. Thermodynamics of surfaces, flotation, adsorption of detergents, electrical double layer, flocculation, dispersion. Prerequisite: Chem. 451.
- 502. FROTH FLOTATION AND AGGLOMERATION (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 501.
- 505. PHYSICAL SEPARATIONS IN MINERAL PROCESSING (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal, and other methods of mineral processing. Prerequisite: Mn.Pr. 401.
- 506. MINERAL PROCESS PLANT DESIGN (3-10) Process design and economy. Development and quantification of flow sheets. Integration of unit operations. Plant layout, equipment selection, and instrumentation. Prerequisite: Mn.Pr. 401.
- 507. (Metal. 507) HYDROMETALLURGICAL PROCESSING (3) Fundamental physico-chemical factors underlying the aqueous extraction and recovery of metals and non-metals from ores, minerals, and scrap metal. Prerequisite: Mn.Pr. (Metal.) 426.
- 508. MINERAL PARTICLE SYSTEMS (3) Creation, characterization, separation, and agglomeration of particles. Comminution, sizing, fractionation of powders; surface area, pore size determinations. Agglomeration and balling.
- 509. PARTICLE-FLUID DYNAMICS (3) Movement of particles in fluids, rheology of non-newtonian mineral suspensions, design of concentrating devices, fluidized beds, electrodynamic, magnetic separations.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

MINING ENGINEERING (MNG E)

LEE SAPERSTEIN, *Section Chairman of Mining Engineering*
104 Mineral Sciences

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Hardy, Lovell, Manula, Ramani, Saperstein, Stefanko, and Voight.

Graduate Faculty: Associate Member Morley.

Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering (ore estimation, cost analysis and control, budgeting); mechanization and mine plant (unit operations, materials handling, continuous mining, power supply); development and exploitation methods (mine planning and layout, design of systems); mine management, production engineering (work and methods analysis, operations analysis); operations research, environmental control and health and safety (gas and dust technology, ventilation, air conditioning, hy-

457. COMPOSITION (2 per term, maximum of 16)
459. ORCHESTRATION AND ARRANGING (3)
465. FORM AND ANALYSIS (2)
466. ADVANCED CONDUCTING (2 per term, maximum of 12)
467. OPERA WORKSHOP (1-6)
468. ADVANCED CHAMBER MUSIC (1-6)
470. CONTEMPORARY TECHNIQUES (3)
500. INTRODUCTION TO MUSIC REFERENCE AND RESEARCH MATERIALS (3) A study of musicological reference and research materials in English and western European languages, with exercises in their use.
- *501. ADVANCED HARPSICHORD (3 per term, maximum of 18) Instruction in harpsichord playing; preparation for recital performance. Fee \$100.
- *503. ADVANCED ORCHESTRAL INSTRUMENTS (3 per term, maximum of 18) Study, repertoire building, and recital performance. Fee \$80.
- *511. ADVANCED PIANO (3 per term, maximum of 18) Piano literature of all periods for public performance. Fee \$80.
- *520. VOICE (3 per term, maximum of 18) Study, repertoire building, and recital performance. Fee \$80.
- *531. ADVANCED ORGAN (3 per term, maximum of 18) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee \$100.
555. ANALYTICAL TECHNIQUES (3) Advanced analysis of music of all periods.
- *558. FREE COMPOSITION (3 per term, maximum of 18) Composition: vocal and instrumental, standard or modern idioms.
- *560. ORCHESTRAL AND CHORAL CONDUCTING (3 per term, maximum of 18) Supervised conducting in selected performance situations, rehearsal techniques and comprehensive score analysis.
572. SEMINAR IN MUSICOLOGY (3 per term, maximum of 9) Research in selected areas of music history.
580. STUDIES IN ORCHESTRAL LITERATURE (3) Selected studies in orchestral literature from the seventeenth century to the present.
581. STUDIES IN CHAMBER MUSIC LITERATURE (3) Selected studies in chamber music of all types from the seventeenth century to the present.
582. STUDIES IN KEYBOARD LITERATURE (3) The literature of major keyboard instruments from the sixteenth century to the present.
583. STUDIES IN CHORAL LITERATURE (3) Selected studies in choral literature of all types from the sixteenth century to the present.
584. STUDIES IN OPERATIC LITERATURE (3) Studies in the development of the opera from 1600 to the present, treating both libretto and music.
585. STUDIES IN VOCAL LITERATURE (3) Selected studies in solo vocal literature of all periods.
586. THEORY SEMINAR (1-6) Seminar in the history, art, and science of music, with readings, and performance.
587. SUBSIDARY COURSE (1-6) Seminar in the history, art, and science of music, with readings, and performance.

*Course may be scheduled only after consultation with the head of the department.

MUSIC EDUCATION (MU ED)

J. DAVID BOYLE, *In Charge of Graduate Programs in Music Education*
263 Chambers Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Boyle, Deihl, and Thompson.

Graduate Faculty: Associate Members Ramsey and Wooderson.

Graduate programs in music education prepare students for careers in public-school music teaching, music supervision, college teaching, administration, or research. It is possible to include study in a number of these areas in the M.Ed. or D.Ed. programs.

Completion of a recognized music education major, or program leading to teaching certification in music, is a prerequisite for admission to the M.Ed. or D.Ed. programs. D.Ed. candidates will spend at least three consecutive terms in residence some time between admission to candidacy and completion of the degree program.

Applicants for the master's program who present a 2.75 junior-senior average and two satisfactory professional references will be considered for admission to the program in music education, provided they have appropriate course backgrounds and musical proficiency. During each candidate's first term in residence, he or she will take a diagnostic examination in music education, music theory, and music history. The examination will provide one basis for planning the candidate's program.

Admission to the doctoral program requires: a junior-senior minimum average of B; approximately half of any graduate credits of A quality; an interview prior to admission; submission of a satisfactory score on the Graduate Record Examination; five recommendations attesting to scholarship, musicianship, and ability to do independent study; and a minimum of two years of successful teaching experience in public or private schools.

The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

MUSIC EDUCATION (MU ED)

- 415. WORKSHOP IN SELECTED MUSIC EDUCATION STUDIES (1-6)
- 445. METHODS, ELEMENTARY GRADES (3)
- 446. THE ELEMENTARY MUSIC SPECIALIST (3)
- 448. METHODS, JUNIOR AND SENIOR HIGH SCHOOLS (3)
- 449. STUDENT TEACHING IN THE ELEMENTARY SCHOOL (2-6)
- 450. STUDENT TEACHING IN THE HIGH SCHOOL (2-6)
- 454. ORCHESTRA AND BAND METHODS AND MATERIALS (3)
- 455. STUDENT TEACHING IN INSTRUMENTAL MUSIC (2-6)
- 468. THE TEACHING OF PIANO (3)
- 469. BAND AND ORCHESTRA TECHNIQUES (3)
- 471. TEACHING MARCHING BAND (3)
- 472. WIND INSTRUMENT MATERIALS (3)
- 473. PSYCHOLOGICAL FOUNDATIONS OF MUSICAL BEHAVIOR (3)
- 474. SELECTING AND DEVELOPING MEASURES OF MUSICAL BEHAVIOR (3)
- 480. CHORAL PROGRAM IN THE SECONDARY SCHOOL (3)
- 487. CHILDREN'S SONGS AND RECORDS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501. PROBLEMS AND PROJECTS IN MUSIC EDUCATION (1-6) Independent work on special topics of music education pertinent to the development of curricula, methods, and materials in music education. Prerequisite: 12 graduate credits in education (including music education).

525. **PROSEMINAR: GRADUATE STUDY IN MUSIC EDUCATION (1-3)** Bibliography; location and evaluation of reference materials; organization, form, style in preparing music education research reports and other papers.
555. **RESEARCH METHODS IN MUSIC EDUCATION (3-6)** Research methods and designs for problems in music education; techniques for studying cognitive, affective, and psychomotor responses to musical stimuli. Prerequisites: Mu.Ed. 525; Ed.Psy. 475; Ed.Psy. 406 or 407.
569. **TRENDS IN INSTRUMENTAL MUSIC (3-6)** Methods and materials for school instrumental ensembles.
570. **CHORAL TECHNIQUE (3-6)** Analysis and evaluation of choral materials appropriate for secondary school chorus; program building; practical rehearsal and conducting techniques. Prerequisite: 6 credits of vocal study.
572. **INSTRUMENTAL PEDAGOGY (1-6)** Independent work on special problems in instrumental music pedagogy. Prerequisite: practical experience and 10 graduate credits in music and/or music education.
573. **THE MATERIALS OF APPRECIATION (3)** Examination of written and recorded materials and appropriate techniques for developing appreciation of music at elementary, secondary, and college levels.
574. **CONTEMPORARY MUSIC CURRICULA IN THE ELEMENTARY SCHOOL (3)** Developing music curricula for the elementary school incorporating current theories, practices, materials and research data.
575. **CONTEMPORARY MUSIC CURRICULA IN MIDDLE AND JUNIOR HIGH SCHOOLS (3)** Instructional materials, procedures, and curricular activities, integration with other subjects.
576. **MUSIC SUPERVISION (3)** Current educational procedures in training music supervisors.
577. **INTERNSHIP IN MUSIC SUPERVISION (3-6)** Internship in schools under supervision of graduate faculty in music education. Prerequisites: C.&S. 581, Mu.Ed. 576.
581. **CONTEMPORARY MUSIC EDUCATION (3)** Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.
590. **COLLOQUIUM (1-3)**
591. **INTERNSHIP IN MUSIC PERFORMANCE TECHNIQUES (1-6)** Internship in selected school or music performance situations other than those in the district where the graduate student is employed.
594. **PEDAGOGY OF MUSIC THEORY, READING, AND EAR TRAINING (3)** Instructional theory and materials basic to teaching music theory, reading, and ear training. Musical instruments, audio-visual devices as aids. Prerequisite: 12 credits in music theory and/or harmony.
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

NUCLEAR ENGINEERING (NUC E)

WARREN F. WITZIG, *Head of the Department*
231 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Diethorn, Foderaro, Jacobs, Jester, Kenney, Klevans, Levine, Palladino, Pillay, Remick, Schultz, and Witzig.

Graduate Faculty: Associate Member Robinson.

Programs of study are individually tailored, and engineering is emphasized through the study of reactor principles — computational methods, transport theory, and nuclear design; plasma principles — waves, analysis, and fusion laboratory; shielding — Monte Carlo and transport methods; reactor systems design — thermal, mechanical, and control; reactor fuels — configuration, radiation effects, and

fuel cycle management; isotope utilization — activation analysis, chemical processes including nuclear medicine; safety analysis — reactor siting, engineered safeguards, and environmental effects. The department offers three degrees at the master's level: M.Eng., M.S. with paper, and M.S. with thesis. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language and proficiency in English.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. General aptitude GRE test results are required. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

NUCLEAR ENGINEERING (NUC E)

- 401. INTRODUCTION TO NUCLEAR ENGINEERING (3)
- 402. NUCLEAR REACTOR DYNAMICS DESIGN (3)
- 405. APPLIED NUCLEAR AND RADIOCHEMISTRY (3)
- 408. RADIATION SHIELDING (3)
- 410-411. NUCLEAR REACTOR THEORY (3 each)
- 415. RADIONUCLEAR APPLICATIONS (3)
- 420. RADIOLOGICAL SAFETY (3)
- 425. (Bio.E. 425) RADIOGRAPHIC IMAGING (3)
- 428. RADIOACTIVE WASTE CONTROL (3)
- 430. DESIGN PRINCIPLES OF REACTOR SYSTEMS (3)
- 431. SYNTHESIS OF NUCLEAR SYSTEMS (3)
- 440. NUCLEAR ENGINEERING LABORATORY I (3)
- 441. NUCLEAR ENGINEERING LABORATORY II (3)
- 444. NUCLEAR REACTOR OPERATIONS LABORATORY (1)
- 490. (E.E. 490) INTRODUCTION TO PLASMAS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. REACTOR ENGINEERING (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: M.E. 412 or Nuc.E. 430; Nuc.E. 411.
- 502. REACTOR ENGINEERING LABORATORY (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 411 (only if more than 1 credit of Nuc.E. 502 is taken).
- 503. THERMONUCLEAR ENGINEERING (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math. 452.
- 505. REACTOR INSTRUMENTATION AND CONTROL (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.
- 506. TWO-BODY KINEMATICS (3) Conservation laws of classical and quantum mechanics and their application to interactions between two bodies. Prerequisite: Math. 72.
- 507. INTERACTION OF RADIATIONS WITH MATTER (3) Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. Prerequisite: Nuc.E. 506.
- 509. RADIATION DAMAGE IN SOLIDS (2) Production of defects by high-energy particles; nature of defects; diffusion and annealing in solids; macro property changes. Prerequisite: Nuc.E. 507.
- 511. NUCLEAR REACTOR MATERIALS (3) Philosophy, selection, technology, use, economics, and performance of materials of major interest in nuclear power reactors today. Prerequisite: Nuc.E. 411.
- 512. NUCLEAR FUEL MANAGEMENT (3) Nuclear fuel inventory determination and economic value through the fuel cycle. Emphasis on calculational techniques in reactor, optimization, and design. Prerequisite: Nuc.E. 411.

520. REACTOR ANALYSIS (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.

521. NEUTRON TRANSPORT THEORY (3) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.

540. (E.E. 540) THEORY OF PLASMA WAVES (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: Nuc.E. 490.

541. (E.E. 541) PLASMA THEORY (3) Advanced topics in kinetic theory, fluctuation theory, micro-instability, and turbulence. Prerequisite: Nuc.E. 540 (E.E. 540).

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

NURSING (NURS)

MARGARET A. NEWMAN, *In Charge of Graduate Program in Nursing*
15 Henderson Human Development Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members Baltes, Gunter, and Newman.

Graduate Faculty: Associate Members Igou, Mandrillo, O'Brien, Rinehart, Susman, Taheri, Waters, and Williamson.

The master of science degree in nursing is offered in recognition of the completion of a program which emphasizes productive scholarship and research in the preparation of the advanced nursing practitioner. The program is accredited by the National League for Nursing (NLN).

Each student must earn a minimum of 40 graduate credits with at least 30 earned as approved resident credits. A core of 9 credits in nursing theory, research, and models of practice is required of all students. Students may select an area of specialization in nursing practice for 21-25 credits (including electives), from among family health, community health and adult health and aging. In addition, 6-10 credits are required for statistics and thesis work; each student must complete a thesis.

Applicants should hold a baccalaureate degree in nursing from an NLN-accredited program and must submit the official results of the verbal and quantitative tests of the Graduate Record Examination. An overall grade-point average of 3.0 on a 4.0 scale is expected for undergraduate work. Courses in basic statistics and introduction to nursing research are required. Applicants who do not meet the established criteria may be considered on an individual basis.

NURSING (NURS)

- 405. OCCUPATIONAL HEALTH NURSING (3)
- 410. NURSING CARE OF THE FAMILY IN THE COMMUNITY (3)
- 425. SCHOOL HEALTH NURSING (3)
- 445. TRAUMA NURSING (3)
- 450. REHABILITATION NURSING (3)
- 455. ADVANCED MEDICAL NURSING (3)
- 460. ADVANCED SURGICAL NURSING (3)
- 486. INTRODUCTION TO NURSING SERVICE ADMINISTRATION (2)
- 490. NURSING STUDY IN SPECIALIZED SETTING (1-12)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501. ISSUES IN NURSING AND HEALTH CARE (2) Consideration of personal, social, political, economic, philosophical, ethical problems/questions and ways of confronting and resolving conflicts in professional practice.
510. THEORETICAL FOUNDATIONS OF NURSING (3) Examines current conceptual models in nursing and relationship of empirical data and existing theories to the development of nursing science.
511. DESIGN AND ANALYSIS OF CLINICAL STUDIES IN NURSING (3) Research design for problems of developing and evaluating nursing care programs, products, methods and procedures. Prerequisite: completion of (or concurrent with) a course in advanced statistics.
522. MEDICATION MANAGEMENT (3) Therapeutic health maintenance principles based upon clinical pharmacology; drug therapy, management; drug metabolism, interaction, side effects, toxic effects, patient teaching. Prerequisite: basic background in principles of pharmacology.
530. CLINICAL PROCESS IN HEALTH CARE AND NURSING (3-10) Supervised experience to develop competence in selected clinical or functional areas of health care or nursing practice. Prerequisite: completion of advanced nursing theory courses in selected clinical or functional areas, or permission of instructor.
550. TRANSCULTURAL HEALTH NURSING (3) Theoretical background for design, implementation, evaluation of nursing care to promote, maintain, and restore health, congruent with cultural patterns.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

NUTRITION (NUTR)

MICHAEL H. GREEN, *In Charge of Graduate Programs in Nutrition*
202 Herderson Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.; M.S. in Nutrition in Public Health

Graduate Faculty: Senior Members Guthrie, Shannon, Wolinsky, and Wright.

Graduate Faculty: Associate Members Green, Massaro, and Sims.

Graduate programs in nutrition prepare students for careers in college teaching, research, industry, and government. The program in nutrition in public health prepares the student for work in public health and community agencies.

To satisfy the communication and foreign language requirement for the Ph.D. degree, students are expected to demonstrate competence in technical writing (e.g., Engl. 418) and spoken English.

For admission to a graduate program in nutrition, a student must have completed at least 6 credits in inorganic and organic chemistry, 3 each in biochemistry, microbiology, and human physiology, 4 in other physical and biological sciences, and 8 in foods and/or nutrition. For admission to the program in nutrition in public health, an additional 12 credits in social sciences are required.

Students with a 2.80 junior-senior average, appropriate course backgrounds, and an acceptable score on the Graduate Record Examination (GRE) or Miller Analogies Test (MAT) will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Students with up to 8 credits of deficiency may also be admitted. Any deficiencies must be completed with a grade of B within two terms.

For other graduate courses in nutrition see A.Ntr. 501, Energy Metabolism, and A.Ntr. 503, Micronutrients: Nutrition, Metabolism, and Function. Current topics are presented as announced in Nutr. 597.

NUTRITION (NUTR)

- 400. INTRODUCTION TO NUTRITION COUNSELING (1-3)
 - 420. EXPERIMENTAL FOODS (4)
 - 421. CULTURAL ASPECTS OF FOODS (3)
 - 422. ADVANCED FOODS (3)
 - 452. NUTRITIONAL ASPECTS OF DISEASE (3)
 - 453. DIET THERAPY (2)
 - 454. LABORATORY METHODS IN NUTRITION (2)
 - 456. COMMUNITY NUTRITION (3)
 - 457. PRINCIPLES OF HUMAN NUTRITION (3)
 - 458. APPLIED HUMAN NUTRITION (2)
 - 459. ADVANCED NUTRITION (3)
 - 490. FOODS AND NUTRITION SEMINAR (1)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
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- 522. ADVANCED EXPERIMENTAL FOODS (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation.
 - 530. PROBLEMS IN FOODS AND NUTRITION (1-6)
 - 550. READINGS IN NUTRITION (3) Readings and reports of selected topics in nutrition.
 - 551. SEMINAR IN NUTRITION (1-6) Selected topics and recent advances in nutrition.
 - 552. NUTRITION IN DISEASE (2) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy.
 - 555. FIELD WORK IN NUTRITION (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged.
 - 556. THE SURVEY METHOD IN FOODS AND NUTRITION (2) Study of survey techniques as a tool in the assay of food adequacy and nutritional status.
 - 557. INTERRELATIONSHIPS OF NUTRIENTS (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition.
 - 558. PROTEIN NUTRITION (2) Classical concepts, recent developments and applied aspects of protein and amino acid nutrition and metabolism. Prerequisite: graduate standing in nutrition or related field.
 - 560. PUBLIC HEALTH NUTRITION (3) Overview of public health nutrition field and profession: administration of public health nutrition programs, including program planning, implementation, and evaluation. Prerequisite: Nutr. 453, 456.
 - 561. PUBLIC HEALTH NUTRITION: PROGRAMS/SERVICES (2) Organization of the nutrition component of programs administered by health agencies; application of knowledge and skills to effect planned change. Prerequisite: Nutr. 560.
 - 590. COLLOQUIUM (1-3)
 - 596. INDIVIDUAL STUDIES (1-6)
 - 597. SPECIAL TOPICS (1-6)
 - 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

OPERATIONS RESEARCH (OR)

M. C. HALLBERG, *Chairman of the Committee on Operations Research*
101 Weaver Building

Degrees Conferred: Students electing this option through participating graduate programs will earn a degree with a dual title at both the Ph.D. and the M.S. or M.A. levels, i.e., Ph.D. in (graduate program name) and Operations Research, or M.S. or M.A. in (graduate program name) and Operations Research.

Graduate Faculty: Senior Members Aggarwal, Antle, L. Austin, Biles, K. W. Crowley, Dinkel, Enscoe, Farouq Ali, Gordon, Gould, Guild, Haight, Hallberg, Harkness, Hayya, Heitmann, Hottenstein, Hu, Ignizio, D. B. Johnson, Kleindorfer, C. G. Knight, Kochenberger, J. Lewis, Mann, Manula, McMurtry, J. Nelson, Parsons, Ramani, Raphael, Rigby, Rosenshine, Shilling, Tilton, Turner, Willenbrock, and A. V. Williams.

Graduate Faculty: Associate Members Beierlein, Chan, Haessel, Kibler, T. A. Ryan, Sani, H. R. Thomas, and Zindler.

The operations research dual-title degree program option is administered by an Operations Research Committee, which is responsible for management of the program. The committee maintains program definition, identifies faculty and courses appropriate to the option, and recommends policy and procedures for its operation to the dean of the Graduate School. This dual-title degree program is offered as an option through graduate major programs in eight colleges. The option enables students from diverse graduate programs to attain and be identified with the tools, techniques, and methodology of operations research, while maintaining a close association with areas of application. Operations research is the analysis — usually involving mathematical treatment — of a process, problem, or operation to determine its purpose and effectiveness and to gain maximum efficiency. To pursue a dual-title degree under this program option the student must apply to the Graduate School and register through one of the following graduate major programs: agricultural economics, business administration, civil engineering, computer science, economics, educational administration, electrical engineering, forest resources, geochemistry and mineralogy, geography, industrial engineering, man-environment relations, mathematics, mineral economics, mining engineering, petroleum and natural gas engineering, and statistics.

For the Ph.D. degree with operations research option, in addition to those prescribed by the graduate major program, prerequisites for acceptance to the program without deficiency include the following or their equivalent: Math. 161, 162, 263, 240, and 72 or 250; Cmp.Sc. 101; and 6 credits in elementary or introductory micro- or macroeconomics. There are no prerequisites for admission to the M.S. or M.A. program option other than those that may be imposed by the participating graduate major programs.

To qualify for a dual-title degree after admission to the program option, students must satisfy the requirements of the graduate major programs in which they are registered, in addition to the minimum requirements, or their equivalent, in the operations research option.

The minimum requirements for the Ph.D. degree with operations research option are: (1) Mathematics — 9 credits minimum including real analysis (Math. 420) and linear algebra (Math. 441); (2) Statistics — 9 credits minimum with a 6-credit sequence in mathematical statistics (Stat. 409, 410) or in experimental statistics (Stat. 401, 402) and 3 credits in stochastic processes (Stat. 427); (3) Optimization — 12 credits minimum including linear programming I and II, mathematical programming I, and dynamic programming; (4) Processes — 9 credits minimum including inventory models, scheduling models, and waiting line models; (5) Computer Science — 6 credits minimum including numerical methods and digital simulation techniques; and (6) Open Areas (application and/or specialization) — 15 credits minimum.

For the M.S. or M.A. degree with operations research option, 18 credits are required from the areas of statistical methods, computer science, optimization (survey-level courses acceptable), processes (survey-level courses acceptable), and applications. (Application courses are those that involve problem solving through the use of decision methods.) At least 3 credits must be selected from each area. Particular courses may satisfy both the graduate major program requirements and those in the operations research option. A thesis may be required, the supervisor of which must be a member of the Graduate Faculty recommended by the chairman of the program granting the degree and approved by the Operations Research Committee as qualified to supervise thesis work in operations research. A paper or report may be written in lieu of the M.S. or M.A. thesis upon approval of the student's graduate major program. A student selecting the paper or report must take an additional 6 credits in the operations

research program. It is the prerogative of the graduate major program to assign these credits to one or more of the following categories: statistical methods, computer science, optimization, processes, and applications.

A Ph.D. minor program in operations research is available for doctoral students in graduate programs who find it advantageous to include advanced quantitative methods of systems analysis in their program of study and have been approved to do so by their doctoral committee. To qualify for a minor in operations research, students must satisfy the requirements of their graduate major program and take at least 15 credits from the following areas: statistical methods or mathematical statistics, computer science, optimization, and processes. At least 3 credits must be taken from each of optimization and processes areas as listed below.

The doctoral committee is recommended by the graduate major program granting the degree. The chairman and at least two members of a doctoral committee must be members of the Graduate Faculty and approved by the Operations Research Committee as qualified to supervise doctoral theses in operations research. The Operations Research Committee is responsible for administering an examination in operations research which constitutes a portion of the comprehensive examination administered to the doctoral student in the program option, as well as to the candidate who chooses operations research as a minor field.

Courses of a like nature identified as the core of the program option have been given generic names and descriptions. Each such listing may be satisfied by one of the courses given under it.

OPTIMIZATION AREA

Linear Programming I An introduction to the theory and methodology of linear programming.

I.E. 405

Q.B.A. 451

Linear Programming II A further treatment of the theory and methodology of linear programming with emphasis on special formulations.

I.E. 510

Mathematical Programming I Introduction to optimization theory designed to provide the necessary fundamentals for nonlinear programming and more advanced studies in mathematical programming.

Q.B.A. 452

Mathematical Programming II An in-depth treatment of nonlinear programming and geometric programming with emphasis on both theory and applications.

Q.B.A. 550

Mathematical Programming III A seminar dealing with recent advances in mathematical programming.

Q.B.A. 550

Dynamic Programming Study of the concepts underlying model building and optimization of dynamic systems, with applications to engineering, economic, and environmental systems.

I.E. 519

Stat 534 (M.E.R. 534)

Goal Programming Study of concepts and methods in analysis of systems involving multiple objectives, with applications to engineering, economic, and environmental systems.

I.E. 520

PROCESSES AREA

Inventory Models A study of inventory theory, deterministic and probabilistic models, single and multiproduct models in single- and multistage processes.

I.E. 508

Mgmt. 518

Scheduling Models Scheduling models with simultaneous job arrival and probabilistic job arrival, network scheduling and scheduling simulation techniques.

I.E. 507

Mgmt. 516

Waiting Line Models Theory of systems involving stochastic delay and stochastic service.

I.E. 509

Stat. 528

OPERATIONS RESEARCH (O R)

590. COLLOQUIUM (1 per term, maximum of 3)

PETROLEUM AND NATURAL GAS ENGINEERING (PNG E)

C. DREW STAHL, *Section Chairman of Petroleum and Natural Gas Engineering*
207 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Burcik, Farouq Ali, and Stahl.

Graduate Faculty: Associate Members Ertekin and Jacoby.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students who expect to enter graduate study in this program with a degree in another major should present 6 credits in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission. Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

PETROLEUM AND NATURAL GAS (P N G)

400. THESIS (1-6)

410. APPLIED RESERVOIR ENGINEERING (3)

420. APPLIED RESERVOIR ANALYSIS (3)

421. RESERVOIR ENGINEERING (3)

430. RESERVOIR MODELING (3)

440. FORMATION EVALUATION (3)

450. DRILLING DESIGN AND PRODUCTION ENGINEERING (3)

475. PETROLEUM ENGINEERING DESIGN (3)
480. PRODUCTION PROCESS ENGINEERING (3)
481. NATURAL GAS AND GASOLINE PLANTS (2)
485. ENGINEERING IN SECONDARY RECOVERY (3)
486. TERTIARY OIL RECOVERY METHODS (3)
493. ENGINEERING EVALUATION OF OIL AND GAS PROPERTIES (3)
510. SOLUTION OF THE PARTIAL DIFFERENTIAL EQUATIONS OF FLOW IN POROUS MEDIA (3) The application of mathematical techniques to solve the partial differential equations of steady and unsteady state flow in porous media. Prerequisite: Math. 405.
511. NUMERICAL SOLUTION OF THE PARTIAL DIFFERENTIAL EQUATIONS OF FLOW IN POROUS MEDIA (3) Differencing schemes for the partial differential equations of single-phase flow; application to flow of gas and mixing in porous media.
512. NUMERICAL RESERVOIR SIMULATION (3) Mathematical analysis of complex reservoir behavior and combination drives; numerical methods for the solution of behavior equations; recent developments. Prerequisite: P.N.G. 510.
513. ADVANCED NUMERICAL RESERVOIR SIMULATION (3) Compositional simulation; history-matching theory; simulation of basic processes involving heat and mass transfer in porous media. Prerequisite: P.N.G. 512.
514. OPTIMIZATION OF PETROLEUM RECOVERY PROCESSES (3) Optimum search methods, linear programming, nonlinear programming, dynamic programming, application to water-flooding, depletion drive, steam injection, gas cycling, miscible displacement. Prerequisite: P.N.G. 410.
515. ADVANCED OIL RECOVERY TECHNIQUES (3) Advanced oil recovery techniques including water-flooding, in situ combustion, steam injection, hot-water injection, and miscible-phase displacement.
519. DESIGN OF THERMAL RECOVERY PROJECTS (3) Suitability of reservoirs for thermal oil recovery; case histories; design of in situ combustion and steamfloods; thermal stimulation; shale oil recovery. Prerequisite: P.N.G. 515.
520. PHASE RELATIONS IN RESERVOIR ENGINEERING (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.
530. NATURAL GAS ENGINEERING (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycle; current developments. Prerequisite: P.N.G. 481.
550. ADVANCED ENGINEERING EVALUATION OF OIL- AND GAS-PRODUCING PROPERTIES (3) Selected topics of current research and development interest in formation evaluation, geophysical well logging and production economics. Prerequisites: P.N.G. 440, 493.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

NOTE: Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under Materials Science.

PHARMACOLOGY (PHARM)

ELLIOT S. VESELL, *Chairman of the Department*
The Milton S. Hershey Medical Center
Hershey, PA 17033

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Berlin, Beyer, Connor, Fritz, Greene, Hayes, Jacob, Severs, and Vesell.

Graduate Faculty: Associate Members Dvorchik, Liu, Lloyd, Passananti, Rose, Schneck, Smith, and Summy-Long.

The graduate studies program in pharmacology is designed to give qualified students a combination of didactic instruction, informal direction, and laboratory experience which will enable them to obtain a firm foundation in the principles, methods, and contributions of pharmacology (defined broadly as the science of the multiple aspects of the interaction of chemical agents with biological systems). With this preparation, graduates of the program should be capable of designing and executing high-quality independent research, and of assuming positions of responsibility within the pharmacologic community.

The department offers studies in the general areas of drug metabolism, molecular pharmacology, endocrine pharmacology, neuropharmacology, cardiovascular-renal pharmacology, and clinical pharmacology. Primary emphasis is placed on the molecular mechanism by which drugs act in the body and by which the body transforms drugs.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required; reading knowledge of one or two foreign languages is recommended. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Two letters of recommendation are required, along with a curriculum vitae and Graduate Record Examination scores.

This program is offered only at The Milton S. Hershey Medical Center.

PHARMACOLOGY (PHARM)

- 501. PHARMACOLOGY (4) Lectures, discussions, and laboratory study of the mechanism of drug action in biological systems.
- 502. PHARMACOLOGY (4) Continuation of Pharm. 501.
- 504. DRUG METABOLISM (3) Study of chemical transformation of drugs within animal cells and drug-metabolizing enzymes present in liver microsomes performing this function. Prerequisite: Pharm. 501.
- 505. PHARMACOKINETICS (3) Quantitation of the time courses of absorption, distribution, metabolism and excretion of drugs in the intact organism. Prerequisites: Pharm. 501, 502, or 520.
- 510. MOLECULAR TURNOVER IN ANIMALS (3) In-depth consideration of the dynamic state of body constituents as applied to carbohydrates, lipids, nucleic acids, and particularly to proteins. Prerequisite: Bchem. 502.
- 511. MOLECULAR MECHANISM OF ACTION OF DRUGS (2) Series of lectures and informal discussion on the molecular mechanism of action of some drugs and their clinical applications. Prerequisite: Bchem. 502.
- 512. CLINICAL PHARMACOLOGY (3) Drug therapy of cardiovascular, renal, and neural diseases.
- 515. HUMAN GENETICS (2) Seminar-type presentations by students and staff on fundamental problems and current topics in human genetics.
- 520. PRINCIPLES OF DRUG ACTION (2) Detailed analysis of basic parameters governing drug actions.

525. **PHARMACOLOGY OF ANTITUMOR DRUGS (2)** Study of the mechanisms of antitumor drug action in biological systems. Prerequisite: Pharm. 501.
530. **PHARMACOLOGY OF PSYCHOTROPIC DRUGS (2)** Systematic analysis of the effects of psychotropic drugs.
540. **PHARMACOGENETICS (3)** Study of human responses to individual drugs.
549. **NEURAL SUBSTRATES FOR DRUG ACTION (2)** Correlation of the sites of action within the central nervous system where certain common drugs exert major effects. Prerequisites: Pharm. 501, 502.
550. **NEUROPHARMACOLOGY (2)** Study of mechanisms of action of drugs which alter neuronal transmission in the peripheral and central nervous systems.
571. **TECHNIQUES IN PHARMACOLOGICAL RESEARCH (2)** Classes will be comprised of lectures by the faculty of the Department of Pharmacology, followed by working demonstrations of the techniques.
575. **DEVELOPMENT OF RENAL DRUGS (3)** The development and clinical application of new therapeutic agents, using one or more prototype drugs as examples. Prerequisites: Pharm. 501, 502.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

PHILOSOPHY (PHIL)

CARL R. HAUSMAN, *Head of the Department*
247 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Anderson, Hausman, Johnstone, Kockelmans, Lingis, Rosen, Seeborn, and Verene.

Graduate Faculty: Associate Members Flay, Ginsberg, Lachterman, Price, Tsugawa, and Vaught.

A thorough grounding in the history of philosophy is desirable for all students. Specialization is possible in areas (such as aesthetics, metaphysics, ethics, social philosophy, logic, and history and philosophy of science); in movements of thought (such as rationalism, empiricism, idealism, phenomenology, and existentialism); or in any of the major figures in the history of western philosophy. Specialization is also possible in a joint program with the Department of Mathematics in logic and the foundations of mathematics, and with the Department of Physics in philosophy of science. Undergraduate preparation to the extent of a strong minor is advisable. The department may waive the requirement of a thesis for an M.A. candidate.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

PHILOSOPHY (PHIL)

406. **MEDIEVAL PHILOSOPHY (3)**
408. **STUDIES IN SOCIAL AND POLITICAL PHILOSOPHY (3)**
410. **STUDIES IN GREEK PHILOSOPHY (3-6)**
411. **STUDIES IN MODERN PHILOSOPHY (3-6)**
412. **STUDIES IN CONTEMPORARY PHILOSOPHY (3-6)**
413. **PHILOSOPHY OF LITERATURE (3)**

414. AESTHETIC THEORY (3)
417. STUDIES IN NINETEENTH-CENTURY PHILOSOPHY (3-6)
419. PHILOSOPHICAL BACKGROUNDS OF AMERICAN THOUGHT (3)
420. PHILOSOPHY OF HISTORY (3)
421. STUDIES IN THE PHILOSOPHY OF SCIENCE (3)
424. STUDIES IN PHILOSOPHY OF RELIGION (3)
426. METAPHYSICS (3-6)
427. ADVANCED ETHICS (3)
428. (Math. 428) LOGICAL THEORY (3)
429. SEMANTICS: PHILOSOPHY OF LANGUAGE AND SYMBOLISM (3)
432. (S.T.S. 432) MEDICAL ETHICS (3)
435. (S.T.S. 435) THE INTERRELATION OF SCIENCE, PHILOSOPHY, AND RELIGION (3)
442. MODAL LOGIC (3)
449. LOGIC IN PHILOSOPHY (3)
494. (Ph.Ed. 494) MAN, WORLD, AND SPORT — A PHILOSOPHICAL INQUIRY (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. ETHICS: HISTORICAL AND SYSTEMATIC (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.
504. SOCIAL AND POLITICAL PHILOSOPHY (3-6) Critical study of basic problems in their historical and functional setting.
505. PHILOSOPHY OF WESTERN RELIGION (3-6) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.
506. SEMINAR IN ANCIENT PHILOSOPHY (3-6) Study of one or more important men or movements in ancient philosophy.
508. SEMINAR IN MODERN PHILOSOPHY (3-6) Men and movements in philosophy from the Renaissance through the nineteenth century.
509. SEMINAR IN CONTEMPORARY PHILOSOPHY (3-6) Men and movements in twentieth-century philosophy.
512. ADVANCED TOPICS IN PHILOSOPHY OF SCIENCE (3-6) Crucial problems in the theory of science and scientific method.
513. (Psy. 513) PRINCIPLES AND METHODS OF EMPIRICAL SCIENCE (3) Scientific methodologies and their presuppositions, with special emphasis on behavioral and social sciences.
514. SEMINAR IN NINETEENTH-CENTURY PHILOSOPHY (3-6) Study of a philosopher or philosophical movement of the nineteenth century.
515. PHILOSOPHICAL METHOD (3-6) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.
516. SEMINAR IN AESTHETICS (3-6) Problems and theories in the nature of art.
526. SEMINAR IN METAPHYSICS (3-6) Formulation and analysis of metaphysical problems in the various fields of philosophy.
530. PHILOSOPHY RESEARCH SEMINAR (1-12) Study of selected philosophical problems with an emphasis on techniques of philosophical research.
543. PROPOSITIONAL AND PREDICATE LOGIC (3) The theory and metatheory of propositional logic, with an introduction to predicate logic.
554. (Math. 554) LOGIC AND METAMATHEMATICS (3) Completeness, Lowenheim-Skolem and compactness theorems. First-order arithmetic, recursiveness, and the incompleteness and consistency of arithmetic. Prerequisite: Phil. 428.
590. COLLOQUIUM (1-3)

597. SPECIAL TOPICS (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

PHYSICAL EDUCATION (PH ED)

KARL G. STOEDEFALKE, *Associate Dean for Academic Affairs*
274 Recreation Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Buskirk, Cavanagh, Christina, Harris, Hodgson, Hunt, Kamon, Landers, Lucas, Lundegren, Mendez, Morehouse, Nelson, and Stoedefalke.

Graduate Faculty: Associate Members Alles, Eck, Gallagher, Magnusson, Nicholas, Sabock, Scannell, Shute, Smith, St. Pierre, and Thompson.

The master's program is research-oriented and is designed to increase a student's professional competence as a teacher and future doctoral candidate, while the doctoral program is directed toward careers in research and in teaching at the advanced undergraduate and graduate levels in colleges and universities. The graduate programs are directed toward involvement of the student in gaining greater depth of understanding regarding the foundations of physical education. All degrees require experience with research to enable the student to better analyze problems, assess information, draw logical conclusions, and apply research findings.

Areas of specialization include (1) adapted physical education, (2) administration-curriculum-supervision, with a sub-area in sports administration, (3) biomechanics, (4) exercise specialist, (5) health education, (6) history of sport and physical education, (7) motor learning, (8) performance assessment, (9) physiology of exercise, (10) psychosocial foundations of physical activity, and (11) recreation and parks.

Admission to the graduate program requires a bachelor's or master's degree in physical education or its equivalent in comparable course work and acceptable performance on the Graduate Record Examination. Especially desirable is a concentration in the physical, biological, behavioral, or social sciences depending upon the intended area of specialization. Admission to doctoral study requires demonstrated research ability in the form of a thesis or published research. A student who has earned a master's degree in recreation and parks and meets the above requirement may enter a doctoral program in physical education with specialization in recreation and parks. Students must demonstrate proficiency in use of the English language. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language—French, German, Russian, Spanish, or another language upon petition.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Graduate Record Examination scores are required for all graduate program applicants.

See also Recreation and Parks.

HEALTH EDUCATION (HL ED)

405. PREVENTION AND CARE OF ATHLETIC INJURIES (3)

408. INJURY CONTROL (3)

411. PRINCIPLES AND METHODS OF TEACHING SAFETY EDUCATION (3)

421. INTEGRATING HEALTH EDUCATION INTO THE SCHOOL PROGRAM, K-12 (3)

443. ALCOHOL EDUCATION (3)

446. HUMAN SEXUALITY AS A HEALTH CONCERN (3)

450. HEALTH EDUCATION PRACTICUM (3-10)

456. ADVANCED TECHNIQUES IN SCHOOL COMMUNITY HEALTH EDUCATION (3)

- 457. CONSUMER HEALTH EDUCATION (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

511. (Anth. 511) HEALTH IMPLICATIONS IN THE GROWTH AND DEVELOPMENT OF SCHOOL CHILDREN (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: HI.Ed. 215.

513. (Anth. 513) HEALTH IMPLICATIONS IN MATURITY AND AGING (3) Changes in the human body in maturity and aging. Theories and mechanisms of physiologic aging with implications for health education. Prerequisite: HI.Ed. 511.

521. PROBLEMS IN SCHOOL HEALTH ADMINISTRATION (3) Critical concerns in the development and coordination of curriculum, policies, and evaluation of health education and services in school systems. Prerequisite: HI.Ed. 456.

530. (Ph.Ed. 530, Rc.Pk. 530) RESEARCH TECHNIQUES IN HEALTH AND PHYSICAL EDUCATION AND RECREATION (3) Research techniques, including methods, research design, techniques for data collection, as applied to relevant problems in the health education field.

552. CURRENT HEALTH EDUCATION ISSUES (3) Analysis of scientific and political foundations of current issues within health education tasks, with emphasis on research and action implications.

PHYSICAL EDUCATION (PH ED)

- 400. ADAPTED PHYSICAL EDUCATION (3)
- 402. PHYSICAL EDUCATION FOR CHILDREN WITH LEARNING PROBLEMS (2)
- 412. CONTEMPORARY PROBLEMS OF TEACHING PHYSICAL EDUCATION IN THE INNER CITY SCHOOLS (3)
- 420. PSYCHOSOCIAL DIMENSIONS OF PHYSICAL ACTIVITY (3)
- 442. SPORT IN ANTIQUITY (3)
- 450. CURRENT RESEARCH LITERATURE IN PHYSICAL EDUCATION (3)
- 452. METHODS, MATERIALS, AND PRINCIPLES OF PHYSICAL EDUCATION IN THE ELEMENTARY SCHOOL (3)
- 455. STATISTICAL METHODS IN HEALTH, PHYSICAL EDUCATION, AND RECREATION (3)
- 456. PHYSICAL FITNESS APPRAISAL (3)
- 457. EXERCISE PRESCRIPTION (2)
- 460. METHODS AND PRINCIPLES OF ATHLETIC COACHING (3)
- 462. ADMINISTRATION OF ATHLETIC PROGRAMS (2)
- 463. ACQUISITION OF MOTOR SKILLS (3)
- 470. HISTORY AND THEORY OF DANCE IN EDUCATION (2)
- 471. EUROPEAN AND AMERICAN FOLK DANCE (2)
- 480. EXERCISE PHYSIOLOGY (3)
- 483. MOTOR PATTERNS OF CHILDREN (3)
- 484. KINESIOLOGY (3)
- 489. INTRAMURAL ATHLETICS (3)
- 490. INTRODUCTION TO TESTS AND MEASUREMENTS IN HEALTH AND PHYSICAL EDUCATION (3)
- 491. ORGANIZATION AND ADMINISTRATION OF HEALTH AND PHYSICAL EDUCATION IN SCHOOLS (3)
- 494. (Phil. 494) MAN, WORLD, AND SPORT — A PHILOSOPHICAL INQUIRY (3)
- 495. HISTORY OF SPORT IN AMERICAN SOCIETY (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

500. (Rc.Pk. 500) INDIVIDUAL STUDY AND RESEARCH PROJECTS (1-10) Prerequisite: Ph.Ed. 530.

520. PSYCHOLOGY OF SPORT (3) Study of man's psychological behavior in sport and physical activity; development of somatopsychic theory of physical activity. Prerequisite: 6 credits in psychology.

522. **SPORT IN SOCIETY (3)** Examination of the cultural phenomenon of sport; social behavior in sport; institution of sport and relationship with other social institutions. Prerequisite: 3 credits in sociology.
525. **SOCIAL PSYCHOLOGY OF SPORT (3)** Theory and research concerning the social-psychological basis for understanding social interaction and performance in team and individual sport settings. Prerequisite: 3 credits in social psychology at the 400 or 500 level.
530. (Hl.Ed. 530, Rc.Pk. 530) **RESEARCH TECHNIQUES IN HEALTH AND PHYSICAL EDUCATION AND RECREATION (3)** Research techniques, including methods, research design, techniques for data collection, as applied to relevant problems in the health education field.
532. **TESTS AND MEASUREMENTS IN PHYSICAL EDUCATION (3)** Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.
534. **STUDIES IN CURRICULUM CONSTRUCTION IN PHYSICAL EDUCATION (3)** Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction.
535. **MODERN FOREIGN SYSTEMS OF SPORT AND PHYSICAL EDUCATION (3)** Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.
550. **SEMINAR IN HEALTH AND PHYSICAL EDUCATION (1-6)** An in-depth analysis of current problems confronting the profession.
560. **ADMINISTRATIVE PROBLEMS OF PHYSICAL EDUCATION IN SCHOOLS (3)** Solutions to problems emerging from the administration of physical education in schools, fitting physical education in the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.
563. **MOTOR LEARNING (3)** Analysis of research evidence related to motor skills; characteristics of beginning and advanced performers; relevant learning principles.
565. **NEUROMUSCULAR PERFORMANCE (3)** Integrative action of the neural and muscular systems in effecting human movement with emphasis on motor performance. Prerequisites: Ph.Ed. 480, 490.
567. (Phsio. 567) **ADVANCED EXERCISE PHYSIOLOGY (3)** Physiological changes during exercise with emphasis on the effects of physical conditioning and training. Prerequisites: Biol. 472, Ph.Ed. 480.
568. (Phsio. 568) **ERGONOMICS (3)** Anthropometric, biomechanical, and physiological characteristics of working man and their importance in the man-machine-environment complex. Prerequisites: Biol. 472, Ph.Ed. 480; I.E. 408 recommended for engineering students.
575. **MOTOR PERFORMANCE OF THE HANDICAPPED (3)** Motor performance of physically handicapped and mentally retarded. Activities and therapeutic exercises for the formulation of individualized programs. Prerequisites: Cn.Ed. 409, E.E.C. 410.
576. **INTERNSHIP IN ADAPTED PHYSICAL EDUCATION (3)** Supervised internship in recreational, educational, or clinical situations; assessment of motor performances, evaluation of activities, and staff conference participation.
577. (Phsio. 577) **APPLIED CARDIOVASCULAR PHYSIOLOGY (2)** In-depth study of cardiovascular system physiology. Prerequisites: 4 credits in physiology at the 400 or 500 level.
580. (Phsio. 580) **ANALYSIS OF BODY COMPOSITION (2)** Study of the methods employed in the analysis of body composition. Prerequisite: Biol. 472 or 3 credits in physiology at the 400 or 500 level.
581. **BIOMECHANICS (3)** Kinetic and kinematic analyses of human motion utilizing electromyography and stroboscopic-photographic techniques. Prerequisite: Ph.Ed. 480.
582. **ADVANCED KINESIOLOGY (3)** Analysis of sports movements utilizing cinematography, electronic devices, and related research instruments.
583. **SPECIAL TOPICS IN BIOMECHANICS (1-6)** Critical review of current research in biomechanics, culminating in individual research projects. Prerequisite: Ph.Ed. 581 or 582.

584. **ELECTROMYOGRAPHIC KINESIOLOGY (3)** The theoretical background and practical application of electromyography in understanding human movement and the function of muscles. Prerequisites: Ph.Ed. 480, 484.
585. (Phsio. 585) **APPLIED PHYSIOLOGY: THERMAL (3)** Physiological mechanisms activated by exposure to environmental temperature. Prerequisite: Ph.Ed. 480 or 3 credits in physiology at the 400 or 500 level.
586. **RESEARCH METHODS IN APPLIED PHYSIOLOGY (3)** Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.
587. (Phsio. 587) **APPLIED PHYSIOLOGY: AMBIENT PRESSURE (3)** Physiological mechanisms activated by exposure to environmental pressure. Prerequisite: Ph.Ed. 480 or 3 credits in physiology at the 400 or 500 level.
588. **SPECIAL TOPICS IN APPLIED PHYSIOLOGY (1-6)** Critical discussion and evaluation of current research in applied physiology. Prerequisite: Ph.Ed. 585.
590. **COLLOQUIUM (1-3)**
595. **PHILOSOPHY OF SPORT AND PHYSICAL EDUCATION (3)** Prerequisite: Ph.Ed. 491 or Rc.Pk. 465.
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

PHYSICS (PHYS)

ROLAND H. GOOD, JR., *Head of the Department*
104 Davey Laboratory

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Barsch, Bleuler, Cutler, Feuchtwang, Fleming, Frankl, Freed, Good, Graetzer, Grotch, Henisch, Herman, Kazes, Kendall, Lang, Madjid, McCammon, McCubbin, Pliva, Polo, Pratt, Reed, Shaw, Strother, Thwaites, Tsong, Vedam, Whitfield, and Wiggins.

Graduate Faculty: Associate Members Cole, Lannin, Lochstet, Maynard, and Sakurai.

Graduate instruction and research opportunities are available in atomic and molecular physics, nonlinear optics, field emission and field ion microscopy, many aspects of solid-state and surface physics, low-temperature physics, ionosphere and vacuum physics, acoustics, physics of biological compounds, nuclear physics, theoretical particle physics, quantum field theory, and general relativity. Work in some areas is conducted in cooperation with the Materials Research Laboratory, the Ionosphere Research Laboratory, and the Applied Research Laboratory. Thesis research toward applied options of the M.S. and the Ph.D. degrees is usually carried out in one of these laboratories.

For the Ph.D. degree, knowledge of a foreign language may be required depending on the area of research. For the M.S. and M.Ed. degrees, the nonthesis option is available subject to approval by the department head.

A bachelor's degree in physics or an allied field is required for admission to the M.S., D.Ed., and Ph.D. programs. Students with a 2.50 or higher junior-senior average in physics and mathematics will be considered, and the best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Exceptions may also be made for applicants for doctoral programs who have completed master's degrees at other institutions.

Admission and study programs for the M.Ed. degree are handled on an individual basis.

PHYSICS (PHYS)

- 400. INTERMEDIATE ELECTRICITY AND MAGNETISM (4)
 - 402. ELECTRONICS FOR SCIENTISTS (4)
 - 406. NUCLEAR PHYSICS (3)
 - 410. INTRODUCTION TO QUANTUM MECHANICS (3)
 - 412. SOLID STATE PHYSICS I (3)
 - 413. SOLID STATE PHYSICS II (3)
 - 419. (A.M., Math. 419) THEORETICAL MECHANICS (3)
 - 420. THERMODYNAMICS (3)
 - 421. KINETIC THEORY AND STATISTICAL MECHANICS (3)
 - 433. MECHANICS AND FLUID PHYSICS FOR TEACHERS (3)
 - 443. INTERMEDIATE ACOUSTICS (3)
 - 454. ATOMIC AND NUCLEAR PHYSICS (3)
 - 456. ATOMIC AND MOLECULAR PHYSICS (3)
 - 457. EXPERIMENTAL PHYSICS (1-2 per term)
 - 458. INTERMEDIATE OPTICS (4)
 - 461. (A.M., Math. 461) THEORETICAL MECHANICS (3)
 - 467. INTERMEDIATE ELECTRICITY AND MAGNETISM (3)
 - 471. QUANTUM THEORY OF ATOMS AND MOLECULES (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
510. GENERAL RELATIVITY (3) Foundations of general relativity; physics of metric spaces, tensor calculus; particle dynamics. Applications to stellar structure and cosmology. Prerequisites: Phys. 530; Phys. 525 or Math. 523.
511. APPLICATIONS OF GENERAL RELATIVITY (3) Einstein's equations; empty and matter-filled spaces; conservation laws; Schwarzschild, Nordström-Reissner and Kerr solutions; solar system tests; gravitational waves. Prerequisite: Phys. 510.
- 512-513. INTRODUCTION TO THE QUANTUM THEORY OF SOLIDS (3 each) Energy band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisites: Phys. 412, 517.
517. STATISTICAL MECHANICS (3) Classical and quantum statistics; statistical thermodynamics; the Boltzmann transport equation; methods illustrated with applications to physical problems. Prerequisites: Phys. 420, 561.
518. ADVANCED TOPICS IN THERMODYNAMICS AND STATISTICAL MECHANICS (3) Selected topics related to nonequilibrium thermodynamics, many-body problem, fluctuations, and statistical theory of random processes. Prerequisite: Phys. 517.
524. PHYSICS OF SEMICONDUCTORS (3) Band structures, theory of electron and hole conduction, transport properties, excess carrier distributions, p-n junctions, metal-semiconductor contacts, semiconductor surfaces. Prerequisite: Phys. 412.
525. METHODS OF THEORETICAL PHYSICS (3) Vector and tensor analysis; generalized coordinate systems; matrices and linear vector spaces of finite and infinite dimensionality; calculus of variations. Prerequisite: advanced calculus.
526. METHODS OF THEORETICAL PHYSICS (3) Continuation of Phys. 525: complex variables; Hilbert space; Green's functions; orthogonal functions and boundary value problems. Prerequisite: Phys. 525.
530. THEORETICAL MECHANICS (3) Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.
532. ADVANCED THEORETICAL MECHANICS (3) Least action principle, canonical transformations, Lagrange and Poisson brackets, Hamilton-Jacobi equations, classical theory of fields. Prerequisite: Phys. 530.

533. THEORETICAL ACOUSTICS (3) Vibrating systems; transmission of disturbances through elastic and viscoelastic media. Prerequisite: Phys. 530.
550. APPLIED GROUP THEORY (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510 or Phys. 525.
- 553-554. NUCLEAR PHYSICS (3 each) Theory of nuclear structure and nuclear reactions; intermediate-energy nuclear theory; pion physics. Prerequisite: Phys. 562.
557. ELECTRICITY AND MAGNETISM (3) Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric and magnetic properties of material media.
558. ADVANCED ELECTRICITY AND MAGNETISM (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.
559. GRADUATE LABORATORY (1) Introduction to techniques and instrumentation used in modern physics laboratories. Includes experience in planning experiments and working in research laboratories.
- 561-562. QUANTUM MECHANICS (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.
- 563-564. ADVANCED QUANTUM MECHANICS (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.
571. ATOMIC PHYSICS (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.
572. MOLECULAR PHYSICS (3) Electronic and nuclear motions in molecules, molecular spectra and structure. Prerequisite: Phys. 571.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6) (e.g., surface physics, tunneling theory, field-ion microscopy, liquid helium, superconductivity, vacuum physics, ion optics, nonlinear optics, many-body theory.)

PHYSIOLOGY (PHSIO)

ELSWORTH R. BUSKIRK, *Chairman of the Committee on Physiology*
119 Noll Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Amann, Anthony, Bullock, Buskirk, Eberhart, Gaffney, Harrison, Hodgson, Hollis, Jefferson, Kamon, LaNoue, Leach, McCarl, Mendez, Morgan, Mortimore, Mueller, Mumma, Nahrwold, Neely, Pegg, Rose, Scholz, Smyth, Wangsness, Whitfield, Wickersham, and Zelis.

Graduate Faculty: Associate Members Green, Li, Mashaly, Mitchell, Neff, Nellis, Nicholas, Rannels, and Wenger.

This is an intercollege program designed to enable students to obtain an integrated series of courses encompassing both the fundamentals of physiology and advanced training in a specialized area. Courses can be taken at either The Milton S. Hershey Medical Center or at University Park.

Graduate instruction in physiology is under the direction of a program committee composed of graduate faculty representing several departments or groups at University Park actively participating in the physiology program — including the areas of animal industry, animal nutrition, biochemistry, bioengineering, biology, biophysics, physical education, psychology, veterinary science, and zoology — as well as the Department of Physiology at The Hershey Medical Center. The instructional staff is composed of faculty in those departments offering graduate courses in various areas of specialization in

physiology. The program, including courses, laboratory experience, and original research, is designed for completion in three to four academic years. The communication and foreign language requirement for the Ph.D. degree may be satisfied by one of several options including intermediate knowledge of one foreign language.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

Deficiencies in chemistry, mathematics (through calculus), physics, or biological science must be made up early in the student's graduate program. All candidates (master's and doctoral) must complete a general basic laboratory course in physiology (combined cellular, mammalian, and comparative) before choosing an area of specialization. Possible areas of specialization are cardiovascular and respiratory physiology; cellular and subcellular physiology; comparative physiology; environmental physiology; exercise physiology; physiology of nutrition and metabolism; neurophysiology; and reproductive physiology. The graduate committee for majors shall be appropriately represented by members of the physiology program committee and those of the area of specialization who shall have the responsibility and jurisdiction for determining the course program and research acceptable in satisfying degree requirements. The nonthesis option is available for the M.S. degree.

The following courses, among others, are available for physiology majors, and their descriptions may be found under the offerings of several departments: Agro. 512, 545; A.I. 510, 514; A.Ntr. 401, 501; Anthy. 507; Bioch. 401, 402, 417, 437, 438, 501, 510, 511, 512, 519; Bio.E. 402; Biol. 409, 428, 437, 472, 473, 479, 538, 539, 550; Bphys. 430, 473, 587, 588; Cmp.Sc. 402, 410; D.Sc. 431; Ed.Psy. 400, 406, 506, 507; E.E. 569; Fd.Sc. 521; Hl.Ed. 511, 513; Meteo. 505; Micrb. 400, 401, 414, 508; Nuc.E. 415, 420; Nutr. 452, 457, 458, 459, 530, 552, 557; Ph.Ed. 456, 480, 565, 586, 588; Phys. 400, 402, 420; Psy. 402, 403, 455, 503; Stat. 451, 461, 462, 464; V.Sc. 405, 418, 525, 528, 535.

The following courses in anatomy and biochemistry are offered at The Milton S. Hershey Medical Center: Anat. 501, 502, 505, 510, 512, 513, 515, 530, 535, 542, 543, 545, 550, 590, 596, 597; B.Chem. 502, 503, 504, 513, 523, 551, 553, 590, 596, 597. Descriptions of these courses may be found under the designated program.

PHYSIOLOGY (PHSIO)

*520. MEDICAL PHYSIOLOGY (2) Cellular physiology including membrane permeability, bioelectric potentials, muscular contractions, secretion; metabolic physiology, including control of metabolism by hormones.

*521. MEDICAL PHYSIOLOGY (3) Organ physiology; examination of respiratory, renal, gastrointestinal and cardiovascular physiology.

*522. PHYSIOLOGY LABORATORY (1) Practical exercises in the areas of neuromuscular physiology, metabolism and endocrinology. Prerequisites: one year of biology, two years of chemistry, and one year of physics. Concurrent: Phsio. 520.

*523. PHYSIOLOGY LABORATORY (1) Practical exercises in the areas of cardiovascular, respiratory, renal and gastrointestinal physiology. Prerequisite: Phsio. 520. Concurrent: Phsio. 521.

*525. GENERAL PHYSIOLOGY (2) Cellular processes of accumulation membrane transport, bioelectric potentials, contraction, and secretion in erythrocytes, nerves, sensory receptors, muscles, glands, excretory organs.

*530. METABOLIC AND ENDOCRINE PHYSIOLOGY (3) Regulation of carbohydrates, fatty acid and protein metabolism; regulation of hormone secretion; effects of hormones on water and cell metabolism.

*532. REPRODUCTIVE PHYSIOLOGY (3) Physiology of mammalian reproductive systems, including synthesis, secretion and mechanism of action of the steroids and polypeptide hormones involved. Prerequisites: Phsio. 520, 521.

*This course is offered at The Milton S. Hershey Medical Center.

- *534. HEART AND SKELETAL MUSCLE (2) Discussion of structure, chemistry, and physiology of heart and skeletal muscle. Prerequisites: Phsio. 520, 521.
- *536. GASTROINTESTINAL PHYSIOLOGY (2) Mechanisms of absorption and secretion by stomach, intestine, pancreas, and gallbladder. Neural and hormonal regulation, bioelectric potentials, pathophysiology. Prerequisite: Phsio. 521.
567. (Ph.Ed. 567) ADVANCED EXERCISE PHYSIOLOGY (3) Physiological changes during exercise, with emphasis on the effects of physical conditioning and training. Prerequisites: Biol. 472, Ph.Ed. 480.
568. (Ph.Ed. 568) ERGONOMICS (3) Anthropometric, biomechanical, and physiological characteristics of working man and their importance in the man-machine-environment complex. Prerequisites: Biol. 472, Ph.Ed. 480; I.E. 408 recommended for engineering students.
571. (Biol. 571) ANIMAL PHYSIOLOGY (2) Mammalian cardiovascular system; mammalian neurophysiology; excitable tissue, sensory systems, motor systems, and autonomic system. Prerequisite: Biol. 472.
572. (Biol. 572) ANIMAL PHYSIOLOGY (2) Mechanisms involved in the activity and control of gastrointestinal function, respiration, and renal regulation of blood and body fluids. Prerequisite: Biol. 472.
573. (Biol. 573) ANIMAL PHYSIOLOGY (2) Hypothalamic-hypophyseal relationships. Reproductive cycle regulation, endocrine control of fluid balance, body temperature, energy homeostasis and metabolism of protein and minerals. Prerequisite: Biol. 472.
577. (Ph.Ed. 577) APPLIED CARDIOVASCULAR PHYSIOLOGY (2) In-depth study of cardiovascular system physiology. Prerequisite: 4 credits in physiology at the 400 or 500 level.
580. (Ph.Ed. 580) ANALYSIS OF BODY COMPOSITION (2) Study of the methods employed in the analysis of body composition. Prerequisite: Biol. 472 or 3 credits in physiology at the 400 or 500 level.
585. (Ph.Ed. 585) APPLIED PHYSIOLOGY: THERMAL (3) Physiological mechanisms activated by exposure to environmental temperature. Prerequisite: Ph.Ed. 480 or 3 credits in physiology at the 400 or 500 level.
587. (Ph.Ed. 587) APPLIED PHYSIOLOGY: AMBIENT PRESSURE (3) Physiological mechanisms activated by exposure to environmental pressure. Prerequisite: Ph.Ed. 480 or 3 credits in physiology at the 400 or 500 level.
589. PHYSIOLOGY OF PULMONARY RESPIRATION (2) Physiology of the lung, including physical and chemical properties, synthesis of cellular constituents, gas exchange, and effects of unusual environments. Prerequisite: 3 credits of physiology at 400 or 500 level.
- †590. COLLOQUIUM (1-3)
- †596. INDIVIDUAL STUDIES (1-6)
- †597. SPECIAL TOPICS (1-6)

†This course is offered at The Milton S. Hershey Medical Center

PLANT PATHOLOGY (PPATH)

SAMUEL H. SMITH, *Head of the Department*
211 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Ayers, Bloom, Boyle, Cole, Kingsolver, Leath, Lukezic, MacKenzie, Merrill, P. Nelson, R. Nelson, Oswald, Pell, Schein, Schisler, Sherwood, Smith, Toussoun, and Wuest.

Graduate Faculty: Associate Members Davis, Frank, Hickey, McCarthy, Pennypacker, Petersen, Romaine, and Stouffer.

Plant pathology is the study of disease in plants and concerns the dynamic interaction between the plant, the causal agent (bacteria, fungi, viruses, nematodes, etc.), and their environments. A student prepares for a professional career in research, teaching, extension, or industry through advanced studies of the principles of plant infection, the physiology of disease in plants, the ecology of root diseases, the nature and inheritance of disease resistance in plants, epidemiology, ecology and physiology of air pollution injury to plants, or plant disease control by biological or chemical means. A student also may specialize in the nature and control of the diseases of forest trees, agronomic or horticultural crops, and commercial mushrooms. Advanced studies in applied mycology, related to the production of the commercial mushroom, also may be taken. Modern, well-equipped laboratories, controlled environment facilities and greenhouses, and well-developed field research areas are available for graduate study.

The Master of Agriculture degree is offered to provide professional training in plant pathology with more of a crop orientation than is available under the M.S. program. In addition to the courses required for an M.S. degree, further study in the areas of entomology and crop sciences is required. A thesis substitute, such as an internship report, or an adaptive or demonstrative activity whereby known technology or procedures are applied, is acceptable.

Competency in foreign language is not required for the Ph.D. degree; however, depending upon the nature of the thesis research and with the advice and consent of the doctoral advisory committee, competency in a foreign language may be judged to be an essential part of the doctoral studies of certain students.

For admission a student must present 42 credits in the natural sciences, including a minimum of 15 credits in the plant sciences and a minimum of 15 credits in mathematics, chemistry, or physics. Students with a strong background in agronomy, biochemistry, biophysics, botany, forestry, genetics, horticulture, or microbiology are usually well prepared for advanced study in plant pathology.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces and advisers that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

PLANT PATHOLOGY (PPATH)

- 401. THEORY AND CONCEPTS OF PLANT PATHOLOGY (3) *Merrill*
- 402. DISEASES OF ECONOMIC PLANTS (2 per term, maximum of 8) *Merrill*
- 403. INTRODUCTION TO EPIDEMIOLOGY (3) *Schein*
- 408. PLANT PATHOLOGICAL TECHNIQUES (3) *Wuest*
- 420. PLANT PATHOGENIC BACTERIA (3) *Lukezic*
- 422. INTRODUCTION TO PLANT VIROLOGY (3) *Romaine*
- 424. ENVIRONMENTAL PATHOLOGY (3) *Davis*
- 429. PHYTONEMATOLGY (3) *Bloom*
- 430. HISTORY OF PLANT PATHOLOGY (2) *Merrill*
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. CLINICAL PLANT PATHOLOGY (1-3) Diagnosis and prognosis of disease; observe and evaluate the implementation of control practices. Prerequisite: P.Path. 408. *Cole*

540. PLANT DISEASE CONTROL (3) Principles of plant disease control, including theoretical considerations involved in control by chemical and nonchemical means. *Cole*
541. PHYSIOLOGY OF PLANT DISEASE (3) Physiology of the diseased plant, including the host response to the pathogen and parasitic properties of the pathogen. Prerequisite: Biol. 443. *Lukezic*
542. EPIDEMIOLOGY OF PLANT DISEASES (4) Disease development in populations of plants, with emphasis on the impact of environment and control practices on rate of development. Prerequisite: 9 credits in plant pathology. *Pennypacker*
543. PATHOGEN VARIATION AND HOST RESISTANCE (3) Mechanisms and implications of genetic variation in plant pathogens related to breeding for disease resistance in plants by genetic means. Prerequisite: P.Path. 401, Agro. 411, or Hort. 407. *Ayers*
544. PATHOLOGICAL PLANT ANATOMY (3) Structural manifestations occurring in diseased plants. Prerequisite: Biol. 407. *P. E. Nelson*
560. PRINCIPLES OF PLANT PATHOLOGY (3) Open-ended discussions of concepts of plant pathology, with emphasis on their interrelationships and their significance to the science. *R. R. Nelson*
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

POLITICAL SCIENCE (PL SC)

JOHN D. MARTZ, *Head of the Department*
112 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Albinski, Aspaturian, Brown, Butterworth, Chang, Eisenstein, Friedman, Gilberg, Harkavy, Keynes, Kochanek, Martz, Myers, and Spence.

Graduate Faculty: Associate Members Cimbala, King, Murphy, O'Connor, and Sarvasy.

Candidates for the M.A. will be comprehensively examined in one of the following fields: American politics, comparative politics, international relations, political theory and methodology, or public administration. Candidates following the thesis plan will also take course work in one other of these substantive fields. Candidates following the nonthesis plan will take course work in two of the above five fields. Ph.D. candidates will be comprehensively examined in three of the above fields, or in two departmental fields, and in a minor field or fields. Course work in scope of the discipline and methodology is required. The communication and foreign language requirement for the Ph.D. may be satisfied by competence in approved skills selected from among foreign languages, statistics or mathematics, and computer science.

Students with a 3.00 junior-senior average and appropriate course backgrounds, including at least the equivalent of 12 credits in political science, will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. At the master's level two letters of recommendation and scores on the Graduate Record Examination (verbal and quantitative ability) are required. Admission to the Ph.D. program will entail evaluation of two letters of recommendation, scores on the Graduate Record Examination (verbal and quantitative ability), and previous scholastic performance.

POLITICAL SCIENCE (PL SC)

401. POLITICAL BEHAVIOR (3) *King and O'Connor*
403. THE LEGISLATIVE PROCESS (3) *Keynes*
409. QUANTITATIVE POLITICAL ANALYSIS (3) *King and Williams*
411. AMERICAN POLITICAL THEORY (3) *Sarvasy and Spence*
412. INTERNATIONAL ORGANIZATION: ECONOMIC AND SOCIAL FUNCTIONS (3) *Harkavy*
413. GOVERNMENT AND POLITICS OF THE SOVIET UNION (3) *Aspaturian and Gilberg*
414. FOREIGN POLICY OF THE SOVIET UNION (3) *Aspaturian*
415. INTERNATIONAL ORGANIZATION: POLITICAL AND SECURITY FUNCTIONS (3-6) *Aspaturian, Brown, Butterworth, and Harkavy*
416. INTERNATIONAL LAW (3) *Butterworth*
417. AMERICAN LOCAL GOVERNMENT AND ADMINISTRATION (3) *Friedman, O'Connor, and Williams*
418. INTERNATIONAL RELATIONS THEORY (3) *Butterworth*
419. BUREAUCRACY AND PUBLIC POLICY (3) *Callaghy, Friedman, and Williams*
422. COMPARATIVE URBAN POLITICS (3) *Gilberg and Myers*
425. GOVERNMENT AND POLITICS OF THE AMERICAN STATES (3) *Friedman and O'Connor*
426. POLITICAL PARTIES (3) *King*
427. POLITICAL OPINION (3) *O'Connor*
431. ANCIENT AND MEDIEVAL POLITICAL THEORIES (3) *Sarvasy and Spence*
433. (L.S. 433) THE LAW OF LABOR-MANAGEMENT RELATIONS (3)
438. NATIONAL SECURITY POLICIES (3) *Brown and Myers*
441. THE AMERICAN LEGAL PROCESS (3) *Eisenstein, Keynes, and Murphy*
442. AMERICAN FOREIGN POLICY (3) *Brown, Butterworth, and Harkavy*
443. CURRENT PROBLEMS IN AMERICAN FOREIGN POLICY (3) *Brown and Butterworth*
444. GOVERNMENT AND THE ECONOMY (3) *Friedman and Williams*
447. CONSTITUTIONAL LAW: THE FEDERAL SYSTEM (3) *Keynes and Murphy*
448. CONSTITUTIONAL LAW: FIRST AMENDMENT FREEDOMS (3) *Keynes and Murphy*
450. CANADIAN AND AUSTRALIAN POLITICS AND FOREIGN POLICIES (3) *Albinski*
451. COMPARATIVE POLITICAL ANALYSIS (3) *Albinski and Martz*
452. GOVERNMENTS AND POLITICS OF EASTERN EUROPE (3) *Gilberg*
453. POLITICAL PROCESSES IN UNDERDEVELOPED SYSTEMS (3-6) *Callaghy, Chang, Kochanek, and Myers*
454. GOVERNMENT AND POLITICS OF AFRICA (3) *Callaghy*
455. GOVERNMENTS AND POLITICS OF WESTERN EUROPE (3) *Gilberg*
456. POLITICS AND INSTITUTIONS OF LATIN-AMERICAN NATIONS (3) *Martz and Myers*
457. INTERNATIONAL POLITICS OF LATIN AMERICA (3-6) *Martz and Myers*
458. GOVERNMENT AND POLITICS OF EAST ASIA (3-6) *Chang*
459. GOVERNMENT, POLITICS, AND INTERNATIONAL RELATIONS OF SOUTH ASIA (3) *Kochanek*
460. LIBERAL AND DEMOCRATIC POLITICAL THEORY (3) *Sarvasy and Spence*
461. AUTHORITARIAN AND ELITIST POLITICAL THEORY (3) *Sarvasy and Spence*
462. MARXIST AND SOCIALIST POLITICAL THEORY (3) *Sarvasy and Spence*
466. COMPARATIVE FOREIGN POLICIES OF WESTERN EUROPE (3) *Brown*
468. INTERNATIONAL RELATIONS OF EAST ASIA (3) *Chang*
469. INTERNATIONAL RELATIONS OF SOUTH ASIA (3-6) *Kochanek*
473. CONSTITUTIONAL LAW: CIVIL RIGHTS (3) *Keynes and Murphy*
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
499. FOREIGN STUDY IN GOVERNMENT (2-6)
500. POLITICAL POWER (3-6) Subject to be announced.
505. EXECUTIVE POWER (3-6)
509. SCOPE AND METHOD OF POLITICAL SCIENCE (3-6) *King and Williams*
512. COMPARATIVE POLITICAL SYSTEMS (3-9) *Albinski, Chang, Kochanek, and Myers*

513. SEMINAR IN COMPARATIVE POLITICAL PARTIES (3-6) Nature, function, organization, and leadership of parties; party systems, political culture, voting, and the institutional framework. *Albinski and King*
515. INTERNATIONAL POLITICS (3-6) *Butterworth and Harkavy*
516. SEMINAR IN INTERNATIONAL RELATIONS THEORY AND METHODOLOGY (3) A detailed analysis of major traditional and contemporary theory-building efforts and contemporary research techniques and orientations in international relations. *Butterworth and Harkavy*
517. INTERNATIONAL ORGANIZATION (3-6) *Aspaturian*
521. MODERN DEMOCRATIC POLITICAL THEORY (3-6) *Sarvasy and Spence*
522. COMPARATIVE FOREIGN POLICIES (3-6) Major policies of selected nations which bear upon the search for international peace and security. *Aspaturian*
523. SOVIET POLITICAL BEHAVIOR (3) Forces which shape rivalries for power; decision-making processes; areas of agreement and dissent. *Aspaturian and Gilberg*
524. FOREIGN POLICIES OF THE SOVIET BLOC (3-6) Major policies, the decision-making process, and the impact upon component members and external rivals for power. *Aspaturian and Gilberg*
525. COMPARATIVE AMERICAN STATE AND LOCAL POLITICS (3-6) Literature and research in comparative state and local political systems in the United States. *Friedman and O'Connor*
527. POLITICS AND LEGISLATIVE BEHAVIOR (3-6) Social factors which shape and determine the attitudes and decisions of American legislators and legislative bodies. *Keynes and King*
529. FEDERAL SYSTEMS (3-6) Features of the American federal system compared with those of other nations using the federal form. *Keynes*
530. PUBLIC LAW (3-6) The nature of law and its role in modern society. *Eisenstein, Keynes, and Murphy*
532. EMPIRICAL POLITICAL THEORY (3-6) The impact of scientific method upon traditional political thought. *King, Spence, and Williams*
546. JUDICIAL PROCESS (3) Court functions in the political process; sources and limits of judicial power; perceptions of the judicial role; judicial decision making. Prerequisite: 12 credits in political science. *Eisenstein and Keynes*
554. AFRICAN POLITICAL SYSTEMS (3-6) Impact of European colonialism; cultural and anthropological factors in political development; modernization and analysis of selected problems in contemporary Africa. Prerequisite: 3 credits of comparative government or international relations at the 400 level. *Brown and Callaghy*
572. (Pub.A. 572) INTERNATIONAL DEVELOPMENT ADMINISTRATION (3-6) The execution of foreign policies through national and international public and private organizations. *Brown and LaPorte*
573. (Pub.A. 573) COMPARATIVE PUBLIC ADMINISTRATION (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Callaghy, LaPorte, and Myers*
574. (Pub.A. 574) SEMINAR IN THE ADMINISTRATION OF UNITED STATES FOREIGN AFFAIRS (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *Brown and LaPorte*
586. THEORY OF BUREAUCRATIC AND ADMINISTRATIVE POLITICS (3-6) The role of the executive in government and politics; theories of administrative organization, organization behavior, and decision-making processes. *Friedman and Williams*
594. READINGS IN POLITICAL SCIENCE (1-6) Directed readings in selected areas of the discipline.
595. RESEARCH IN POLITICAL SCIENCE (1-6) Directed research in selected areas of the discipline.
597. SPECIAL TOPICS (1-6)

POULTRY SCIENCE (PTYSC)

KENNETH GOODWIN, *Head of the Department*
214 Animal Industries Building

Degrees Conferred: M.S.

Graduate Faculty: Senior Members Buss, Goodwin, Graves, Leach, MacNeil, Mast, and Mueller.

Graduate Faculty: Associate Member Mashaly.

The department offers two types of degree programs: (1) an M.S. degree in Poultry Science, with one of the following major fields of interest: animal nutrition, behavior, food science, genetics, management, and physiology, or (2) an M.S. or Ph.D. degree in one of the following disciplinary interdepartmental programs: animal nutrition, ecology, genetics, and physiology. In either case, direction of the student's program will be by a faculty member in the Department of Poultry Science. For the Ph.D., reading ability in one foreign language is required.

Students with professional interests other than research may earn the M.S. in Poultry Science without doing a thesis; in this option, a paper on a selected professional problem is required for graduation.

Admission requirements include 30 credits in the biological and physical sciences (chemistry, mathematics, and physics). Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

POULTRY SCIENCE (PTYSC)

405. POULTRY PRODUCTION TECHNOLOGY (3)

462. (Biol. 462) ANIMAL BEHAVIOR — ETHOLOGY (3)

463. (Biol. 463, Psy. 463) ANIMAL BEHAVIOR LABORATORY (1-2)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

502. POULTRY NUTRITION (2-4) *Leach*

503. POULTRY FARM MANAGEMENT (3) An analysis of poultry farm management problems and the application of research methods to a specific problem.

504. POULTRY MEAT AND EGG TECHNOLOGY (3) Analysis of current industry programs, effects of specific procedures on product quality, development of research programs. Offered even years.
MacNeil

582. (Biol. 582, Psy. 582) RESEARCH IN ANIMAL BEHAVIOR (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Graves and Hale*

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

NOTE: See *Animal Science* under "Other Graduate Courses."

PSYCHOLOGY (PSY)

ROBERT M. STERN, *Head of the Department*
417 Moore Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Borkovec, Cornwell, Craighead, Draguns, Farr, Gorlow, Guthrie, Hall, Kazdin, Landy, Leibowitz, Lundy, Mahoney, Martin, Mitzel, Nelson, Noble, Palermo, Piers, Ravizza, Ray, Seibel, Sherif, Shotland, Stern, Taylor, Thevasos, Thomas, Urban, Warren, and Weimer.

Graduate Faculty: Associate Members Dubin, Newcombe, and Whaley.

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, cognition, human information processing, perception, psycholinguistics, verbal learning and memory, physiological and comparative, clinical, developmental and child, engineering and human factors, industrial-organizational, social.

The communication and foreign language requirement for the Ph.D. degree does not specify a foreign language, but a student must demonstrate proficiency in English.

Requirements for admission include a broad undergraduate preparation, a minimum of 9 credits in psychology, and a satisfactory graduate student rating on the Miller Analogies Test and the Graduate Record Examination (general and advanced). Students with a 3.40 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.40 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants with master's degrees will have their admission evaluated with emphasis on the quality of their graduate programs.

PSYCHOLOGY (PSY)

402. SENSATION AND PERCEPTION (3)
403. INTRODUCTORY PHYSIOLOGICAL PSYCHOLOGY (3)
404. CONDITIONING AND LEARNING (3)
405. THE EXPERIMENTAL PSYCHOLOGY OF VISUAL PERCEPTION (3)
408. COMPARATIVE PSYCHOLOGY (3)
409. TECHNIQUES IN LABORATORY EXPERIMENTATION (2-6)
410. HISTORICAL ANTECEDENTS OF PSYCHOLOGY (3)
411. SYSTEMS OF PSYCHOLOGY AND THE RECENT PAST (3)
412. ABNORMAL PSYCHOLOGY (3)
413. BIOGRAPHICAL PSYCHOLOGY (3)
414. HUMANISTIC PSYCHOLOGY (3)
415. INTERMEDIATE EXPERIMENTAL DESIGN (3)
417. SOCIAL PSYCHOLOGY (3)
418. MEASUREMENT OF PERSONALITY (3)
419. MEASUREMENT AND SCALING (3)
420. (Ling. 420) ADVANCED PSYCHOLINGUISTICS (3)
421. ADVANCED COGNITIVE PSYCHOLOGY (3)
425. CHILD PSYCHOLOGY (3)
426. ADOLESCENCE (2-3)
430. MEMORY AND VERBAL LEARNING (3)
431. INDUSTRIAL PSYCHOLOGY (3)
432. INTRODUCTORY ENGINEERING PSYCHOLOGY (3)
433. PSYCHOLOGY OF OCCUPATIONAL BEHAVIOR (2)
434. INFORMATION-PROCESSING LABORATORY (1-6)
435. (M.E.R. 435) ENVIRONMENTAL STIMULATION AND BEHAVIOR (3)
436. MENTAL HEALTH IN SCHOOLS (3)
437. PSYCHOLOGY OF ADJUSTMENT (3)

- 438. THEORY OF PERSONALITY (3)
- 441. INDUSTRIAL MOTIVATION AND MORALE (3)
- 445. (I.F.S. 445) DEVELOPMENT THROUGHOUT ADULTHOOD (3)
- 450. (Ed.Psy. 450) PRINCIPLES OF MEASUREMENT (3)
- 455. PHYSIOLOGICAL PSYCHOLOGY LABORATORY (3)
- 456. LABORATORY IN PSYCHOPHYSIOLOGY (2-4)
- 457. EXPERIMENTAL SOCIAL PSYCHOLOGY (4)
- 463. (Biol. 463, Pty.Sc. 463) ANIMAL BEHAVIOR LABORATORY (1-2)
- 470. (I.F.S. 470) SOCIAL LEARNING FOUNDATIONS OF BEHAVIOR CHANGE (3)
- 471. PSYCHOLOGY AND WOMEN (3)
- 474. PSYCHOLOGY OF EXCEPTIONAL CHILDREN (3)
- 482. INTRODUCTION TO CLINICAL PSYCHOLOGY (3)
- 483. THE PSYCHOLOGY OF FEAR AND STRESS (3)
- 484. CLINICAL NEUROPSYCHOLOGY (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

503. PHYSIOLOGICAL PSYCHOLOGY (2-6) Correlations between structure and function of nervous system and human consciousness; laws and theories in fields of sensation, attention, association, affection, and thought. Prerequisite: 9 credits in psychology.

505. RESEARCH PROBLEMS IN PSYCHOLOGY (1-15) Prerequisite: 12 credits in psychology.

510. HISTORY OF THE HIGHER MENTAL PROCESSES (3) Stress upon theoretical, conceptual, and methodological problems involved in studying human thinking, language, memory, cognition, and other skills. Prerequisite: Psy. 410 or 411.

511. SEMINAR IN CONTEMPORARY PSYCHOLOGY (1-9) Critical review of readings on a topic of current interest, either in content or methodology, within psychology. Prerequisite: 9 credits in psychology.

513. (Phil. 513) PRINCIPLES AND METHODS OF EMPIRICAL SCIENCE (3) Scientific methodologies and their presuppositions, with special emphasis on behavioral and social sciences.

515. ADVANCED STATISTICS IN PSYCHOLOGY AND EDUCATION (3) Correlation theory and methods, discriminant analysis, and factor analysis; applications to mental test theory. Prerequisite: Psy. 415 or Ed.Psy. 506.

516. SEMINAR IN QUANTITATIVE MODELS (3-9)

517. ADVANCED SOCIAL PSYCHOLOGY (3) Problems of theory and of research methods with emphasis on persisting issues relevant to contemporary developments in social psychology. Prerequisites: Psy. 417; Psy. 15 or Stat. 200.

518. PROJECTS IN EXPERIMENTAL PSYCHOLOGY (2-4) Individual experimental projects; seminars on experimental design and instrumentation.

520. (Ling. 520) SEMINAR IN PSYCHOLINGUISTICS (3) Consideration of theoretical and research issues relevant to psychological aspects of language sounds, syntax and semantics, and other cognitive support.

522. PERSONNEL SELECTION AND APPRAISAL (3) Evaluation of models for personnel selection, placement, and performance appraisal in business and industry. Prerequisites: Psy. 431, Psy. 450 (Ed.Psy. 450).

523. SOCIAL-ORGANIZATION PSYCHOLOGY IN INDUSTRY (3) Analysis of the role of social and organizational variables as they affect employee performance and employee attitudes. Prerequisite: Psy. 431.

527. STATISTICAL INFERENCE AND EXPERIMENTAL DESIGN (3) Probability theory, sampling distributions, analysis of variance and covariance, analysis of trend, nonparametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 506.

529. (I.F.S. 529) SEMINAR IN CHILD DEVELOPMENT (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.
531. SEMINAR IN PERFORMANCE THEORY (3-9) Topics in theory and research on human performance in perceptual-motor and information-processing tasks. Prerequisite: Psy. 432.
533. ADVANCED ENGINEERING PSYCHOLOGY (3) Analysis of the role of the human operator in man-machine systems. Prerequisite: Psy. 432.
534. PRACTICUM IN INDUSTRIAL/ORGANIZATIONAL PSYCHOLOGY (1-3) Supervised application of psychological principles in industrial and governmental settings. Prerequisite: Psy. 431.
535. DEVELOPMENTAL PSYCHOLOGY (2-3) Developmental principles and concepts applied to psychological processes, with special reference to the experimental literature. Prerequisite: 9 credits in psychology.
536. (I.F.S. 536) RESEARCH METHODS IN DEVELOPMENTAL PROCESSES (3) Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology, and a course in statistics.
538. PSYCHOLOGY OF PERSONNEL DEVELOPMENT (3) Industrial training in relation to psychological learning theory and experimental findings. Prerequisite: Psy. 431 or Ed.Psy. 421.
539. SEMINAR IN MOTIVATION AND EMOTION (3-9) Systematic status of instinct, drive, motive, will, purpose; methodology and results of physiological, experimental, and clinical investigation of basic drives.
540. SEMINAR IN CLINICAL PROBLEMS (1-9) Contemporary psychological theory, research, and methodology in relation to clinical psychology. Prerequisites: Psy. 542, 560.
541. PERSONALITY THEORY (3-4) Contemporary theories of personality; relevant research. Prerequisite: Psy. 438.
542. PSYCHOPATHOLOGY (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisite: Psy. 412.
543. RESEARCH DESIGN IN CLINICAL PSYCHOLOGY (3) Experimental and quasi-experimental designs, methodological problems, and techniques of experimental control in clinical psychology research. Prerequisite: 3 credits of statistics.
545. SEMINAR IN VERBAL LEARNING AND VERBAL BEHAVIOR (1-9)
549. (I.F.S. 549) DEVELOPMENTAL THEORY (3) Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.
555. THEORY AND PRACTICUM IN CLINICAL ASSESSMENT (3-9) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of testing procedures and clinical interviewing. Prerequisites: Psy. 541 or 542, and a course in measurement.
558. CLINICAL CHILD PSYCHOLOGY (3-9) Psychopathology of childhood; theories of etiology; diagnosis and treatment. Prerequisites: Psy. 555, 561.
559. (S.Psy. 559) THE INDIVIDUAL PSYCHOLOGICAL EXAMINATION (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.
560. PRACTICUM IN CLINICAL METHODS (1-6) Supervised practice in the Psychology Clinic, including assessment, therapy, report writing, and staff participation. Prerequisite: Psy. 555.
561. CLINICAL PRACTICUM WITH CHILDREN (1-6) Diagnosis and counseling of child-parent problems of learning and adjustment. Prerequisites: Psy. 425, 426, 555.
563. BEHAVIOR MODIFICATION I (3) Conceptual foundations of principles, assessment methods, and research strategies.

564. **BEHAVIOR MODIFICATION II (3)** Survey and empirical evaluation of treatment strategies. Prerequisite: Psy. 563.
565. **SEMINAR IN COMMUNITY PSYCHOLOGY (3)** Application of social psychological research methods and principles to prevention and alleviation of behavior disorders in family and community settings.
566. **CULTURAL PSYCHOLOGY (3)** Experimental and descriptive research on culture and behavior in both Western and non-Western settings. Prerequisites: Psy. 417, 438, and 6 credits of statistics.
569. **ADVANCED THEORY AND PRACTICUM IN COUNSELING AND PSYCHOTHERAPY (3-9)** Theoretical issues, research, and practicum experience in psychotherapy.
571. **SEMINAR IN SOCIAL PSYCHOLOGY (3-9)** Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research.
580. **THEORY AND CONSTRUCTION OF ATTITUDE SCALES (3)** Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.
582. (Biol. 582, Pty.Sc. 582) **RESEARCH IN ANIMAL BEHAVIOR (2-6 per term)** Research in special areas of animal behavior involving field or laboratory work.
583. **DESIGNING RESEARCH IN SOCIAL PSYCHOLOGY (3)** Comparative analysis of major methodological approaches including laboratory experiments, field experiments, quasi-experiments, and surveys. Prerequisites: Psy. 417; 3 credits in statistics.
584. **ATTITUDE FORMATION AND CHANGE (3)** Theory and method in research on attitude formation and change with emphasis on critical analysis and research problems. Prerequisites: Psy. 417; 3 credits in statistics.
585. **INTERACTION PROCESSES WITHIN AND BETWEEN GROUPS (3)** Small group processes as context for behavior and for self system. Emphasis on theory and research in laboratory and field. Prerequisites: Psy. 417; 3 credits in statistics.
586. **THE SOCIAL PSYCHOLOGY OF COLLECTIVE ACTION (3)** Social movements, crowds, audiences, and large groups explored for their impact upon the behavior of the individual member. Prerequisite: Psy. 417.
589. **PROBLEMS IN CLINICAL RESEARCH (1-6)** Prerequisite: Psy. 415.
590. **COLLOQUIUM (1-3)**
591. **SEMINAR ON TEACHING PSYCHOLOGY (1-3)** Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

PSYCHOSOCIAL SCIENCE (PS SC)

ROBERT COLMAN, *In Charge of the Graduate Program in Psychosocial Science*
The Capitol Campus, Middletown, PA 17057

Degree Conferred: M.Ps.Sc.

Graduate Faculty: Senior Members Hudson, Lear, Nichols, and Whittaker.

Graduate Faculty: Associate Members Barton, Colman, Dexter, Knestrick, Shuttlesworth, Taylor, and Towns.

The program emphasizes practicum experience to equip students with necessary skills to cope effectively with the problems facing communities. Graduates of the program should be able to recognize

problems, to outline and implement possible solutions to these problems, and to evaluate the effectiveness of the solutions. To perform these functions the student must be aware of contemporary community needs, the impact of the community structure upon its individual members, and the techniques best suited to initiate productive change. Problems in drug abuse, delinquency, unemployment, housing, and other areas affecting the individual may be approached from a community agency base or from less formal community groups dealing with the problems.

The student is required to take 33 credits, 21 at the 500 level. The required practicum experience is field work under the supervision of a faculty member. A paper is required and will be defended orally before a committee of two faculty members and a staff member from the practicum site.

For admission, a student must have received a baccalaureate degree from an accredited institution with residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. Most applicants have degrees in psychology or sociology; however, experience in community agencies is weighed for applicants from other disciplines. Ordinarily, applicants are expected to be familiar with elementary statistics and may be requested to make up any deficiency without graduate credit. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Required courses include: So.Sc. 510, 520; Ps.Sc. 511, 521, 530. Elective courses for a public agency emphasis are: Ps.Sc. 500, So.Sc. 541, 542, 543. Elective courses for an emphasis in community organizing are: Ps.Sc. 500, So.Sc. 531, 532, 533. The majority of these courses are offered in the evening.

Additional courses may be taken from the following list and from any other graduate course list with the approval of the student's adviser: Admin. 500, 510, 560; Geog. 420; Ps.Sc. 407, 421, 430, 461, 470, 596, 597; P.Adm. 550, 551; R.Pl. 400; and So.Sc. 430, 440, 442, 443, and 590. Descriptions of those courses not given below may be found under the designated fields of study.

This program is offered only at the Capitol Campus. Details of application procedures should be requested from Admissions, The Capitol Campus, Middletown, PA 17057.

PSYCHOSOCIAL SCIENCE (PS SC)

401. SEMINAR IN PSYCHOSOCIAL SCIENCE (3)

407. SMALL GROUPS (3)

421. BEHAVIOR MODIFICATION (3)

430. SOCIAL JUDGMENT (3)

461. THEORIES AND MODELS OF COUNSELING (3)

470. ADVANCED STATISTICAL AND DESIGN METHODS (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

500. THEORIES AND ISSUES IN COMMUNITY PSYCHOLOGY (3) Contemporary issues in community psychology will be discussed within the framework of its development from clinical and social psychology.

511. PSYCHOPATHOLOGY IN A SOCIAL CONTEXT (3) Psychopathology in the context of other forms of social deviancy, with attention to both social and individual concomitants of deviancy.

512. THEORIES AND MODELS OF PSYCHOTHERAPY (3) Survey of methods/theories used to treat mental illness or to change dysfunctional behavior. Prerequisites: Ps.Sc. 461, 511.

521. PRACTICUM (3-9) Experience in a field setting with problems confronting both clients and social welfare agencies. Prerequisites: So.Sc. 510, 520.

530. RESEARCH (1-6) Supervised research on a master's paper. For degree candidates only.

535. BEHAVIORAL MANAGEMENT (3) Analysis of the social determinants of behavior and behavioral ecology. Emphasis on data collection and evaluation techniques. Prerequisite: Ps.Sc. 421.

570. ADVANCED EXPERIMENTAL DESIGN (3) A survey of advanced statistical methods and experimental design techniques for community psychology, behavior management, and the social sciences. Prerequisites: Ps.Sc. 470, So.Sc. 520.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

SOCIAL SCIENCE (SO SC)

440. THE CITY (3)

443. SOCIAL CONFLICT (3)

510. CHANGE PROCESSES (3) Social change as it takes place within institutions and communities.

520. TECHNIQUES IN ACTION RESEARCH (3) Methods for evaluating programmatic change. Prerequisite: So.Sc. 320.

531. THE FUNCTIONING NEIGHBORHOOD (3) A study of small communities and techniques for observing them, coupled with field experience in participant observation of a specific neighborhood.

532. COMMUNITY ORGANIZING: CONFLICT AND CHANGE (3) The development of local issues and strategies for organizing around them.

533. PROBLEMS OF THE DISENFRANCHISED (3) Problems confronting minority or low-power groups, with an emphasis on the poor, blacks, and women.

541. THE ORGANIZATION OF HUMAN SERVICES (3) Divisions of labor among social agencies; internal and external factors affecting the ordering of priorities.

542. SOCIAL STRATIFICATION (3) Empirical and theoretical examinations of inequalities in wealth, prestige, and power.

543. COMPLEX ORGANIZATIONS: CHANGE AND RESISTANCE (3) Structure and function in large organizations and case studies of change.

590. COLLOQUIUM (1-3)

597. SPECIAL TOPICS (1-6)

PUBLIC ADMINISTRATION (PUB A)

ROBERT J. MOWITZ, *Director of the Institute of Public Administration*
211 Burrowes Building

Degree Conferred: M.P.A.

Graduate Faculty: Senior Members LaPorte, Lee, and Mowitz.

Graduate Faculty: Associate Members McDavid, Poister, Stevens, Stipak, and Webster.

All candidates take a core program consisting of seven seminars which cover the theoretical, methodological, and technological components of public management science. An additional 9 credits may be elected, permitting the student to focus upon such areas as general public administration, systems analysis, management information systems, urban systems administration, natural resources administration, human resources administration, or any other related substantive area. Course work may be taken at University Park or at the Radnor Center for Graduate Studies. Admission is authorized by the University Park program director.

Candidates for admission ordinarily have at least 12 credits of undergraduate work in the social sciences. Candidates for the degree may be required to take some courses without graduate credit in order to complete a major designed for their professional needs.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for stu-

dents with special backgrounds, abilities, and interests. Scores from the Graduate Record Examination (aptitude test) and two letters of recommendation are required.

PUBLIC ADMINISTRATION (PUB A)

400. INTRODUCTION TO THE AMERICAN ADMINISTRATIVE SYSTEM (3) *Mowitz*
 402. METHODS OF PROGRAM ANALYSIS (3) *McDavid, Poister, Stipak, and Webster*
 403. PUBLIC MANAGEMENT TECHNOLOGY (3) *LaPorte and Lee*
 404. URBAN MANAGEMENT (3) *Lee, McDavid, Poister, and Stipak*
 445. ADMINISTRATIVE LAW (3) *Lee and Mowitz*
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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570. ADMINISTRATION IN MULTI-JURISDICTIONAL SYSTEMS (3) Analysis of multi-jurisdictional constraints on administration; design of strategies for developing and executing programs in a pluralistic institutional setting. *LaPorte, Lee, McDavid, and Poister*
 571. THEORY OF PUBLIC ADMINISTRATION (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice. *Mowitz, Stevens, and Stipak*
 572. (Pl.Sc. 572) INTERNATIONAL DEVELOPMENT ADMINISTRATION (3-6) The execution of foreign policies through national and international public and private organizations. *LaPorte*
 573. (Pl.Sc. 573) COMPARATIVE PUBLIC ADMINISTRATION (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *LaPorte*
 574. (Pl.Sc. 574) SEMINAR IN THE ADMINISTRATION OF UNITED STATES FOREIGN AFFAIRS (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *LaPorte*
 575. GOVERNMENT MANPOWER MANAGEMENT (3) Government personnel systems; current trends and problems; essentials of recruitment, classification and pay, ratings, supervision, training, and discipline. *LaPorte, Lee, Stevens, and Webster*
 576. GOVERNMENT FISCAL DECISION MAKING (3) The role of the executive in fiscal planning; budget preparation; expenditure control; tax assessment and collection; investment of public funds. *LaPorte and Lee*
 577. ORGANIZATION AND SYSTEMS MANAGEMENT (3) Principles of government organization; management surveys; work measurement; methods of achieving efficiency and economy. *Mowitz, Stevens, and Stipak*
 578. URBAN ADMINISTRATIVE SYSTEMS (3) Urban areas as administrative and policy systems; urban responses to problems of policy planning and implementation; approaches to urban analysis. *Lee, McDavid, and Poister*
 579. METHODS OF ANALYSIS AND MEASUREMENT IN PUBLIC ADMINISTRATION (3 per term, maximum of 6) Examination and application of analytical techniques for evaluating organizational performance and program effectiveness in government agencies. *McDavid, Poister, Stipak, and Webster*
 580. INTERNSHIP IN PUBLIC ADMINISTRATION (1-6) *Mowitz*
 581. PUBLIC MANAGEMENT INFORMATION SYSTEMS (3) Examination of the role of management information in public organizations; establishment of information requirements for public programs. Prerequisites: Pub.A. 571, 579. *Stevens and Webster*
 582. LEGISLATIVE MANAGEMENT AND OVERSIGHT FUNCTIONS (3) Examination of the role of the legislature in overseeing the executive; emphasis on financial and program analysis techniques and problems. *Mowitz*

584. RESEARCH SEMINAR IN PUBLIC ADMINISTRATION (1-6) Application of research methods to problems of organization, management, and policy in public agencies; preparation of research project and report. *Mowitz*

597. SPECIAL TOPICS (1-6) *Mowitz*

PUBLIC ADMINISTRATION (P ADM)

DANIEL M. POORE, *Chairman of the Public Administration Program*
The Capitol Campus, Middletown, PA 17057

Degree Conferred: M.P.A.

Graduate Faculty: Senior Members Gilmore and Masters.

Graduate Faculty: Associate Members Bresler, Chisholm, McKenna, Munzenrider, Poore, Skok, Willets, and Woodruff.

This interdisciplinary program is intended to prepare individuals for professional careers as administrators, project directors, or staff analysts in local, state, or federal government, health care organizations, welfare agencies, and other public service organizations. Applicants are expected to present adequate preparation in American government, college algebra, introductory statistics, economics, accounting, computer methods, and the social and behavioral sciences or equivalent experience, or take work not for graduate credit in those areas.

The degree requires a minimum of 45 credits, including 9 credits of faculty-supervised field study in a public agency in the student's field of interest. The 9-credit field-study requirement may be waived for students who have at least three years of full-time professional experience in relevant administrative or staff work prior to graduation.

The 9-credit field-study course extends over three terms (about nine months) at 3 credits per term. It involves about twenty hours per week during two of the terms and about forty hours per week during the summer term. The field study is integrated with the other course work. The location of the Capitol Campus at the state capital of Pennsylvania provides excellent opportunities for field-study experiences in state government agencies, cities and smaller municipalities, county and federal agencies, large hospitals, Penn State's Milton S. Hershey Medical Center, and other professional and public-service organizations.

Full-time graduate work must be started in September, except under special circumstances. The time required to complete the program as a full-time student is normally eighteen months, including the field-study experience in a public agency.

Part-time students may start the program at the beginning of any term. They usually take one 3-credit course each term but may be permitted to take two courses during a term if their past academic performance is very good and their job situation permits. If a part-time student has sufficient professional work experience to waive the 9-credit field-study requirement, the graduate program can be completed in three years or less.

Students with a 3.00 junior-senior average will be considered for admission. Exceptions may be made for applicants with special backgrounds, abilities, and interests, or with professional experience. Applicants are expected to submit their aptitude scores on the Graduate Record Examination, a short essay outlining their career plans, and two letters of reference. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

COURSES*

ADMIN. 500. ADMINISTRATIVE THEORY (3)

ADMIN. 505. PERSONNEL MANAGEMENT (3)

*Descriptions of courses with Admin. designations can be found under that field of study.

ADMIN. 510. ORGANIZATION BEHAVIOR (3)

ADMIN. 515. LABOR MANAGEMENT RELATIONS (3)

ADMIN. 520. ADMINISTRATIVE MODELS (3)

ADMIN. 552. STATISTICAL RESEARCH METHODS (3)

P.ADM. 500. PUBLIC ORGANIZATION AND MANAGEMENT (3) Development of public administration; administrative theory and practice in public organizations. Prerequisites: 3 credits of American government, 6 credits of behavioral science, and 3 credits of micro/macro economics.

P.ADM. 501. ADMINISTRATION AND THE POLITICAL PROCESS (3) Analysis of the relationship of administration to the political processes that shape public policy formulation and execution. Prerequisites: 3 credits of American government and 3 credits of micro/macro economics.

P.ADM. 502. GOVERNMENTAL FISCAL DECISION MAKING (3) Nature, function, and technique of governmental budgeting viewed as mechanism for allocating resources among alternative public uses. Prerequisites: P.Adm. 500, 501.

P.ADM. 503. RESEARCH METHODS (1-3) Examination of research methodologies relevant to administration and public policy. Prerequisite: 3 credits in statistics.

P.ADM. 504. LEGAL AND SOCIAL CONTEXT OF PUBLIC ADMINISTRATION (3) The legal framework for public administration, the administration of public law, conduct of legal research, and socio-legal issues. Prerequisite: 3 credits in American government.

P.ADM. 520. QUANTITATIVE MODELS FOR PUBLIC ADMINISTRATORS (3) Applications of quantitative models for the administrator's viewpoint. Explanation of the underlying models, assumptions made, questions explored, without mathematical detail. Prerequisite: one course in introductory statistics and completion of computer workshop

P.ADM. 530. FIELD STUDY IN PUBLIC ADMINISTRATION (1-3 per term, maximum of 9) Analysis and written reports on current problems/projects for a public agency in student's concentration area. Readings in concentration area. Prerequisite: permission of program chairman.

P.ADM. 532. URBAN GOVERNMENT (3) Administrative processes and policy problems associated with managing urban communities; political, intergovernmental, fiscal, structural, and analytical concepts in urban government.

P.ADM. 540. ADMINISTRATIVE POLICY FORMULATION (3) Analysis of administrative problems from a total organization viewpoint. Case studies of actual organizations are used for analysis.

P.ADM. 546. HEALTH PLANNING FOR PUBLIC ADMINISTRATION (3) Comprehensive planning and program planning for health services, facilities, and manpower; social, economic, and political considerations; methodological problems. Prerequisite: one course in introductory statistics and permission of program head.

P.ADM. 550. PROGRAM PLANNING AND EVALUATION (3) Analysis and evaluation of public programs and systems from the perspectives of policy development and administrative planning and management.

P.ADM. 554. MASTER'S PROJECT (1-3) Student independently executes an applied professional or research project, involving the analysis of a management or a public policy problem. Prerequisite: P.Adm. 503.

P.ADM. 556. STATE GOVERNMENT ADMINISTRATION (3) Study of structures, systems, processes, problems, and issues affecting state government administration; case studies, field observations, and research. Prerequisite: Admin. 500, P.Adm. 501.

P.ADM. 557. FEDERALISM AND INTERGOVERNMENTAL RELATIONS (3) Study of the impact of a federal system of government on the administration of public functions. National-state-local dimensions. Prerequisite: P.Adm. 501.

P.ADM. 558. LEGISLATIVE PROCESSES (3) Legislatures in American government emphasizing comparative state legislatures: constitutional patterns; organization, administration; interaction with bureaucracy, constituencies, and organized interests. Prerequisite: Admin. 500, P.Adm. 501.

P.ADM. 590. COLLOQUIUM (1-3)

P.ADM. 596. INDIVIDUAL STUDIES (1-6)

P.ADM. 597. SPECIAL TOPICS (1-6)

RECREATION AND PARKS (RC PK)

KARL G. STOEDEFALKE, *Associate Dean for Academic Affairs*
274 Recreation Building

Degrees Conferred: M.S., M.Ed.

Graduate Faculty: Senior Members Kandó, Lundegren, Stodefalka, and van der Smissen.

Graduate Faculty: Associate Members Christiansen, Elliott, Farrell, Godbey, Guadagnolo, and Myers.

The graduate program is designed to prepare students for administrative, supervisory, research, and teaching positions in public recreation and park systems, in colleges and universities, in voluntary agencies, and in institutions.

The program is oriented to meet the specific needs and research interests of the candidate. Students may pursue interests in the community, including public park and recreation systems, quasi-public and voluntary agencies, and private enterprises; institution and community-oriented therapeutic settings concerned with many different disabilities and utilizing a variety of activity modalities; and camping and outing activities, park planning, interpretive services, outdoor education, and outdoor recreation services.

The master's degree may be earned in the major program of recreation and parks. At the doctoral level, the Ph.D. and D.Ed. may be earned with a specialization in recreation and parks within the physical education major. Detailed information is available from the department.

For admission to the graduate program, a bachelor's or master's degree is required, preferably in recreation and parks. Candidates from other majors are welcome to apply; however, additional course work is required. Students with a 3.00 junior-senior average and with appropriate course-backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

RECREATION AND PARKS (RC PK)

- 420. OUTDOOR RECREATION (3)
- 421. WATER-ORIENTED OUTDOOR RECREATION (3)
- 425. INTERPRETIVE SERVICES (3)
- 427. OUTDOOR RECREATION PROGRAM SERVICES (3)
- 429. INTERPRETIVE PLANNING (2)
- 430. OUTDOOR EDUCATION: METHODS AND MATERIALS (3)
- 433. EVALUATION IN RECREATION AND PARKS (3)
- 440. ADMINISTRATION OF ENVIRONMENTAL PROGRAM OPERATIONS (3)
- 450. RECREATION ISSUES (1)
- 456. RECREATION PROGRAM ORGANIZATION (3)
- 458. DYNAMICS OF RECREATION GROUPS (3)
- 460. LEGAL ASPECTS OF RECREATION AND PARKS (3)
- 462. (Soc. 462) THE SOCIOLOGY OF LEISURE (3)
- 465. ADMINISTRATION OF RECREATION AND PARKS (3)
- 470. PARK MANAGEMENT (3)
- 475. THERAPEUTIC RECREATION IN THE COMMUNITY (3)
- 477. THERAPEUTIC RECREATION SERVICES (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

500. (Ph.Ed. 500) **INDIVIDUAL STUDY AND RESEARCH PROJECTS (1-10)** Prerequisite: Rc.Pk. 530.
515. **PROGRAM DEVELOPMENT AND SUPERVISION (3)** Critical analysis of the individual, political, and societal determinants of recreation programming; demonstration projects; evaluative procedures, research functions in programming. Prerequisite: Rc.Pk. 456.
520. **SEMINAR IN ENVIRONMENTAL EDUCATION ADMINISTRATIVE PROBLEMS (3)** Focus upon use of the outdoors by special groups in resident and nonresident settings. Prerequisite: Rc.Pk. 230 or 430.
522. **SEMINAR IN CURRICULUM, SUPERVISION AND EVALUATION OF ENVIRONMENTAL EDUCATION PROGRAMS (3)** Prerequisite: Rc.Pk. 430.
525. **BEHAVIORAL PATTERNS OF THE OUTDOOR RECREATIONIST (3)** Patterns of time and space use; user characteristics; meaning of participation; facilitation of environment-use enhancement. Prerequisite: Rc.Pk. 420.
530. (Hl.Ed. 530, Ph.Ed. 530) **RESEARCH TECHNIQUES IN HEALTH AND PHYSICAL EDUCATION AND RECREATION (3)** Research techniques, including methods, research design, techniques for data collection, as applied to relevant problems in the health education field.
533. **RECREATION STUDIES, SURVEYS, AND APPRAISALS (3)** Advanced research procedures related to special recreation and park problems. Prerequisites: Rc.Pk. 530 and 3 credits in statistics.
540. **PUBLIC AND PRIVATE RECREATION LANDS AND WATERS (3)** Public and private roles and interactions, allocation of resources, use policies, open space concepts, private enterprise developments, legal controls.
542. **ENVIRONMENTAL LAW (3)** Legislative, judiciary, administrative processes-roles; citizen action; legal concepts, litigation and enforcement tactics for protection and enhancement of natural environment.
550. **SEMINAR IN RECREATION AND PARKS (1-6)**
560. **ADMINISTRATIVE PROBLEMS OF RECREATION AND PARKS (3)** Special problems of recreation and park departments; legal powers and liability; departmental organization, financing, personnel policies, and staff development. Prerequisite: Rc.Pk. 465.
570. **CONCEPTUAL BASES FOR THERAPEUTIC RECREATION (3)** Issues in the application of concepts in therapeutic recreation from a multidisciplinary perspective; evaluation and research. Prerequisite: Rc.Pk. 477.
590. **COLLOQUIUM (1-3)**
595. **PHILOSOPHICAL AND SOCIAL BASES OF RECREATION (3)** Philosophical and social bases of recreation; analysis of critical issues of recreation for philosophical and social implications.
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

REGIONAL PLANNING (R PL)

HAYS B. GAMBLE, *Chairman of the Graduate Program in Regional Planning*
213 Willard Building

Degree Conferred: M.R.P.

Graduate Faculty: Senior Members J. Coyle, Gamble, Larson, Lee, J. Miller, Newman, and Young.

Graduate Faculty: Associate Members Erickson, Loukissas, and B. Myers.

The graduate program in regional planning emphasizes a multidisciplinary approach to the planning process for multijurisdictional areas, both urban and rural. The program's basic intent is to develop technically competent regional planners who are aware of the social, political, economic, and physical

purposes of planning. A strong feature of the program is that it provides a broad opportunity for a student to pursue a sequence of courses in a special option or to earn a concurrent degree in a planning-related discipline. A nonthesis option is available for the MRP degree. Graduates of the program are employed in planning agencies in all levels of government and in private industry.

For admission a student must have had at least one course in each of the following areas: statistics, economics, ecology, sociology, public administration *or* political science, and physical geography *or* cartography. Applicants must submit scores on the Graduate Record Examination with their applications. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered up to the number of spaces available. Exceptions to the 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

REGIONAL PLANNING (R PL)

400. PRINCIPLES OF REGIONAL PLANNING (3-6)

410. PLANNING PROGRAMS (3)

440. PROBLEMS IN COMMUNITY AND REGIONAL PLANNING (1-9)

502. REGIONAL SYSTEMS ANALYSIS (3-6) Spatial structure of regional and interregional systems; theories of regional development; spatial measures of location, density, central tendency, and dispersion.

503. THEORY AND METHOD OF PLANNING (3) Analysis of normative models of planning processes: social, economic, political, and behavioral assumptions, and methodological problems of evaluatory planning performance.

510. PLANNING TECHNIQUES AND ANALYSIS I (3) Regional socioeconomic structure, problems, and factors in planning; data collection, analysis, and implications.

520. PLANNING TECHNIQUES AND ANALYSIS II (3) Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.

530. PLANNING TECHNIQUES AND ANALYSIS III (3) Effects of political, cultural, and physical factors on planning.

531. PLANNING AND THE LAW (3) Sources of legal power, its transfer among governmental units; nature of regulatory power and legal constraints upon planning decision making.

540. PROBLEMS IN REGIONAL PLANNING (1-9) Planned individual projects involving library, laboratory (studio), or field work.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

RELIGIOUS STUDIES (RL ST)

YOSHIO FUKUYAMA, *Head of the Department*
1001 Liberal Arts Tower

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Cherry, Fukuyama, Harrison, Harshbarger and Prebish.

Graduate Faculty: Associate Members Buckley, Cohn, Lowrie, Stephens, Van Herik, and Vastyan.

The emphasis of this program is on the comprehensive understanding of the various facets of religion in American culture. A broad cross-disciplinary scope is encouraged in substantive areas with particular emphasis on the development of religious thought and movements and the relationships between religion and society. The student will share responsibility with the faculty in shaping a program.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

Applications will be evaluated on the basis of the quality of undergraduate, graduate, or professional records and on the basis of the candidate's clarity of understanding and interest in the specific emphases of the program. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Graduate Record Examination scores, letters of recommendation, and a statement of the applicant's career goals and academic interests are required.

RELIGIOUS STUDIES (RL ST)

- 401. SEMINAR IN COMPARATIVE RELIGION (3 per term, maximum of 6)
- 402. Seminar in Contemporary Religious Thought (3 per term, maximum of 6)
- 408. HINDUISM (3)
- 409. BUDDHISM (3)
- 411. SEMINAR IN JUDAISM (3)
- 421. CULTURE AND RELIGIOUS REFORM (3)
- 422. RELIGION AND AMERICAN CULTURE (3 per term, maximum of 6)
- 430. SEMINAR IN RELIGIOUS ETHICS (3)
- 438. (Soc. 438) RELIGION AND URBAN SOCIETY (3)
- 461. (Soc. 461) SOCIOLOGY OF RELIGION (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 500. THEORIES OF RELIGION (3-6) Cross-disciplinary study of two or more systematic theories of religion: anthropological, phenomenological, philosophical, psychological, sociological, or theological.
- 502. STUDIES IN COMPARATIVE RELIGIONS (3-6) Cross-cultural comparative studies of two or more world religions.
- 505. SEMINAR IN ASIAN RELIGIONS (3-6) Studies in selected Asian religions.
- 521. ISSUES IN WESTERN RELIGION (3-6) Seminar. Study of selected issues in Western religion.
- 522. ADVANCED STUDIES IN AMERICAN RELIGION (3-6) In-depth inquiry into either a period, a movement, or a topic of American religion.
- 524. MAJOR WESTERN RELIGIOUS THINKERS (3-6) Systematic inquiry into the religious thought of major Western religious thinkers.
- 530. RELIGION AND SOCIETY (3-6) Studies of mutual influences and effects of religion and secular phenomena.
- 532. RELIGION AND SOCIAL PROBLEMS (3-6) Study of a selected social issue, or constellation of issues, with analysis of its religious and normative dimensions.
- 536. RELIGIOUS STRUCTURES AND PROCESSES (3-6) Study of the relationship between religion as social structure and as a dynamic social function.
- 539. ADVANCED STUDIES IN RELIGIOUS ETHICS (3-6) A systematic study of the structure and essential themes of ethics of religious institutions and thinkers.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

RURAL SOCIOLOGY (R SOC)

JOHN W. MALONE, JR., *Head of the Department of Agricultural Economics and Rural Sociology*
6A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Bealer, Brown, Crawford, Malone, Stokes, Warland, Wilkinson, and Willits.

Graduate Faculty: Associate Members Crider, Heasley, Leadley, Moore, and Rodefeld.

All degree programs emphasize a comprehensive understanding of the various facets of societal organization pertinent to the rural sector. While scope is encouraged, areas of special interest and research include: consumer behavior, instigated social change, community structure, leadership, population, rural health, rural community services, the structure of agriculture, and the ecology of rurality in industrialized and urbanized society. All students are required to have training in sociological theory, statistics, and research methods.

There is no foreign language requirement for the Ph.D. degree; the student is expected to substitute such courses and instruction necessary to generate superior capabilities of inquiry into an analysis of basic and/or applied rural sociological problems.

Prerequisites for the master's program include 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If the entering student does not have these prerequisites, they must be made up at the University during the early part of the master's program.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

RURAL SOCIOLOGY (R SOC)

- 402. CONSUMER BEHAVIOR AND THE AGRICULTURAL INDUSTRY (3) *Herrmann*
 - 405. LEADERSHIP FOR SOCIAL CHANGE (3) *Heasley*
 - 425. POVERTY ANALYSIS: PEOPLE AND PROGRAMS (3) *Van Horn*
 - 444. THE RURAL TRANSITION IN AMERICAN SOCIETY (3) *Leadley*
 - 452. RURAL ORGANIZATION (3) *Wilkinson*
 - 456. RURAL COMMUNITY SERVICES (3) *Odd years, Leadley; even years, Crawford*
 - 459. RURAL SOCIAL PSYCHOLOGY (3) *Willits*
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
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- 501. DEVELOPMENT OF RURAL SOCIOLOGY (2) Historical development with emphasis on American rural sociology. *Odd years. Crider*
 - 502. ADVANCED RURAL SOCIOLOGY (3) Structure and functioning of rural society; evaluation of theoretical systems. *Even years. Bealer*
 - 510. RURAL MIGRATION (2) Rural migration research and theory; application to governmental and community problems. *Odd years. Stokes*
 - 513. SOCIOLOGY OF CONSUMER BEHAVIOR (2) Sociological theory and research pertaining to consumer behavior. *Odd years. Warland*
 - 514. VALUES IN RURAL SOCIETY (2) Values as dynamic forces in rural society. *Odd years. Bealer*
 - 515. EXTENSION ORGANIZATION AND METHODS (3) Agricultural and home economics extension as a social system, with emphasis on techniques of organization and program development. *Thompson*
 - 516. CHANGE IN RURAL SOCIETY (2) Social change in rural society, emphasizing prediction and control of the change process. *Even years, Crider; odd years, Wilkinson*

551. RURAL SOCIOLOGY SEMINAR (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.

596. INDIVIDUAL STUDIES (1-6)

SCHOOL PSYCHOLOGY (S PSY)

JOSEPH L. FRENCH, *Chairman of the Committee on School Psychology*
104 CEDAR Building

Degrees Conferred: D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members DiVesta, French, Gorlow, Horan, Keat, Salvia, Weener, and Withall.

Graduate Faculty: Associate Members Bagnato, Berlin, Craighead, and Snyder.

This intercollege program is based primarily on courses in counselor education, educational psychology, psychology, and special education. In addition, courses are often drawn from individual and family studies, cultural foundations of education, educational administration, and curriculum and instruction.

The objective is to develop a psychologist who is interested in and knowledgeable about education and psychology in the school setting. The school psychologist must utilize professional skill and knowledge about children and youth to make contributions which are meaningful to, and utilized by, teachers, other school personnel, and parents. The development of competences needed by a fully qualified school psychologist requires at least the education represented by a doctoral degree. Only those students who anticipate a doctoral degree will be admitted. Exceptions may be made for students with special backgrounds, abilities, and interests. Students are selected within the limitations of program facilities. Priority is given to applicants with work experience with children.

An undergraduate major emphasizing work in psychology and/or education is preferred, but students with fewer than 15 upper-division credits in psychology, educational psychology, or special education may be admitted with limited deficiencies to be fulfilled concurrently with their graduate work. Requirements for admission include a minimum junior-senior scholastic average of 2.85 or, for applicants with master's degrees, a minimum of one-third of graduate credits of A quality; satisfactory recommendations from two or more professors, preferably psychologists; and 500 or higher on the general sections of the Graduate Record Examination, 58 or higher on the Miller Analogies Test, and/or 35 or higher on the Quantitative Evaluative Device.

Practicum facilities, in addition to those in nearby public schools, include the Center for Educational Diagnosis and Remediation, the School Psychology Clinic, the Speech Pathology and Audiology Clinic, the Reading Center, the Psychology Clinic, and the Campus Demonstration School for handicapped children. Facilities for work with children are also available through other academic units, as well as through assistantship assignments.

The program has been accredited by the American Psychological Association. Students completing the School Psychology Core Program will have courses in the biological bases of behavior, the cognitive-affective bases of behavior, the social bases of behavior, personality theory, abnormal psychology, human development, professional ethics and standards, research design and methodology, statistics, psychometrics, counseling theory, educational foundations, educational administration, the education of exceptional children, and curriculum. Following the comprehensive examination, an internship is required.

SCHOOL PSYCHOLOGY (S PSY)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

500. PROFESSIONAL ISSUES IN SCHOOL PSYCHOLOGY (1-3) Orientation to the field through study of unique problems, current issues, ethical and legal matters, unique cases, and research projects.

504. PRACTICUM IN SCHOOL PSYCHOLOGY (1-6) Clinical experience with children under supervision in a variety of settings requiring service, including practice in synthesizing data and observations.
508. INTERNSHIP IN SCHOOL PSYCHOLOGY (1-10) Long-term placement in settings providing work for school psychologists with children, parents, teachers, administrators, and service agencies, under supervision.
510. SUPERVISION OF SCHOOL PSYCHOLOGISTS (1-10) Program supervision and professional leadership in university clinics and school systems. Prerequisite: S.Psy. 504.
559. (Psy. 559) THE INDIVIDUAL PSYCHOLOGICAL EXAMINATION (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.
596. INDIVIDUAL STUDIES (1-6)

SLAVIC LANGUAGES AND LITERATURES (S L L)

WILLIAM R. SCHMALSTIEG, *Head of the Department of Slavic Languages*
N-440 Burrowes Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members Birkenmayer, Magner, Paternost, and Schmalstieg.

Graduate Faculty: Associate Members Gebhard and Ivanits.

Opportunities for specialization in literature or linguistics are available. A minimum requirement for admission is an undergraduate major in Russian or its equivalent.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The department prefers that M.A. candidates in this major submit a term paper rather than a thesis.

RUSSIAN (RUS)

426. DOSTOEVSKY (3)
427. TOLSTOY (3)
430. METHODS AND MATERIALS FOR TEACHING RUSSIAN (3)
450. HISTORY OF THE RUSSIAN LANGUAGE (3)
460. LINGUISTIC ANALYSIS OF CONTEMPORARY RUSSIAN (3)
495. PROBLEMS IN RUSSIAN (3-9)

*1G. TECHNICAL RUSSIAN FOR GRADUATE STUDENTS (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

*2G. RUSSIAN TEXTS (3) Development of skill in translating Russian texts in the sciences and social sciences. Prerequisites: Rus. 5 or 1G.

501. READINGS IN RUSSIAN LITERATURE (3-6) Prerequisite: Rus. 204.

525. PUSHKIN (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

540. EIGHTEENTH-CENTURY RUSSIAN LITERATURE (3) Study of the major writers and literary developments in this period of the secularization and modernization of Russian literature.

*No graduate credit is given for this course.

542. SEMINAR IN SOVIET LITERATURE (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.
570. OLD RUSSIAN LITERATURE (3) Analysis of Russian literary monuments in the original, 1100-1700. Prerequisite: Slav. 550.
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

SLAVIC (SLAV)

500. BIBLIOGRAPHY AND RESEARCH TECHNIQUES (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literatures.
510. STRUCTURE OF THE SOUTH SLAVIC AND WEST SLAVIC LANGUAGES (3-12; 3 credits per language) Linguistic analysis of a particular South Slavic (Bulgarian, Macedonian, Serbo-Croatian, Slovenian) or West Slavic (Czech, Lusatian, Polish, Slovak) language. Prerequisite: Rus. 460 or one graduate course in linguistics.
550. OLD CHURCH SLAVIC (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

SOCIOLOGY (SOC)

ROLAND J. PELLEGRIN, *Head of the Department*
201B Liberal Arts Tower

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Buck, DeJong, Faulkner, Pellegrin, Simirenko, Snyder, Steffensmeier, Theodorson, and Westby.

Graduate Faculty: Associate Members Austin, Bord, Clogg, Gelman, Humphrey, Johnson, Mitchell, Raphael, Sauer, Sim, and Taylor.

The M.A. and Ph.D. programs center on training in basic social theory and methodology and the empirical findings in the various areas of sociology. Departmental offerings cover a wide range, including courses and seminars in most fields of specialization in the discipline. The program is designed with considerable flexibility so that students can adapt course work outside the department to their individual interests and goals. One foreign language and work in computer science, philosophy of science, or mathematics may be used to fulfill the Ph.D. degree communication and foreign language requirement. All first-year students who intend to pursue doctoral work are expected to earn an M.A. degree in their normal progress to the Ph.D. The department offers two options leading to the M.A. For the M.A. preparatory to the Ph.D., students must write a thesis and pass qualifying examinations. For the terminal M.A., students must submit a professional paper approved by a committee of three faculty members.

Undergraduate training in sociology is expected. Students of ability who are deficient in undergraduate preparation may be accepted with provisions to make up course deficiencies in the early part of their graduate program. Candidate selection is based on the following information: quality undergraduate academic performance, above-average Graduate Record Examination scores, letters of recommendation, an essay giving the applicant's interests, goals, and purposes for graduate work in sociology, and submission of written work from the student's undergraduate program, such as a term paper. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

The population issues program is a course of study focusing on the social, economic, and geographic policy-related issues arising from the dynamics of population trends, especially in developed nations.

In addition to departmental admission requirements, the population issues committee evaluates the student's interest and aptitude for the training program, which consists of a minimum of 21 credits of interdisciplinary course work in population.

Other areas of study related to sociology, such as rural sociology, community development, cultural anthropology, developmental psychology, and political behavior, are offered in other departments of the University.

Special departmental research and training facilities include the Liberal Arts Data Laboratory, small groups research laboratory, and a sociology reference library. Additional University facilities used by sociology faculty and graduate students include the Computation Center, the Inter-University Consortium of Political Research, the Institute of Public Administration, the Institute for Research in Human Resources, and the Center for the Study of Religion and Human Resources.

SOCIOLOGY (SOC)

- 400. ADVANCED GENERAL SOCIOLOGY (3)
- 401. SOCIAL INSTITUTIONS (3)
- 402. MAJOR ISSUES IN CONTEMPORARY SOCIOLOGICAL THEORY (3)
- 403. ADVANCED SOCIAL PSYCHOLOGY (3)
- 404. SMALL GROUPS (3)
- 406. SOCIOLOGICAL ANALYSIS OF DEVIANCE (3)
- 407. CORRELATES OF POVERTY (3)
- 408. SOCIAL ECOLOGY (3)
- 410. SOCIAL PSYCHOLOGY OF HEALTH (3)
- 412. CRIME AND SOCIAL CONTROL (3)
- 413. METHODS AND TECHNIQUES OF SOCIAL RESEARCH (3)
- 415. THE URBAN COMMUNITY (3)
- 416. (C.F.Ed. 416) SOCIOLOGY OF EDUCATION (3)
- 417. INTRODUCTION TO SOCIAL WORK PRACTICE (3)
- 419. RACE RELATIONS (3)
- 420. FIELD WORK IN SOCIAL WELFARE (3-6)
- 421. SOCIAL GROUP WORK (3)
- 422. HISTORY OF SOCIOLOGICAL THEORY (3)
- 423. SOCIAL DEMOGRAPHY (3)
- 424. SOCIAL CHANGE (3)
- 426. PUBLIC WELFARE POLICY AND SERVICES (3)
- 427. SOCIAL CASEWORK (3)
- 429. SOCIAL STRATIFICATION (3)
- 430. FAMILY IN CROSS-CULTURAL PERSPECTIVE (3)
- 431. SOCIAL WORK PROCESSES (3)
- 432. COLLECTIVE BEHAVIOR (3)
- 433. SOCIAL WORK PRACTICE ANALYSIS (2)
- 434. SOCIAL WELFARE POST-PLACEMENT SEMINAR (1)
- 435. SOCIAL GERONTOLOGY (3)
- 436. (Journ. 436) SOCIOLOGY OF OPINION FORMATION (3)
- 438. (Rl.St. 438) RELIGION AND URBAN SOCIETY (3)
- 444. COMPLEX ORGANIZATIONS (3)
- 446. POLITICAL SOCIOLOGY (3)
- 447. (M.E.R. 447) ENVIRONMENTAL SOCIOLOGY (3)
- 450. COMMUNITY ORGANIZATION (3)
- 453. (Anthy. 453) PRIMITIVE RELIGION (3)
- 454. (L.S. 454) INDUSTRY AND THE COMMUNITY (3)
- 455. (L.S. 455) THE SOCIOLOGY OF WORK (3)
- 458. SOCIAL WORK IN THE COMMUNITY (3)
- 461. (Rl.St. 461) SOCIOLOGY OF RELIGION (3)
- 462. (Rc.Pk. 462) THE SOCIOLOGY OF LEISURE (3)
- 470. INTERMEDIATE SOCIAL STATISTICS (4)

473. METHODS OF DEMOGRAPHIC ANALYSIS (3-6)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
499. FOREIGN STUDY IN SOCIOLOGY (2-6)
500. SEMINAR IN GROUP THEORY (1-3) The group as a unit of social structure and action.
502. THEORIES OF SOCIETY (3) Past and present theories of the overall structure and processes of societal functioning.
503. RESEARCH SEMINAR IN SOCIAL PSYCHOLOGY (3-6) Design and conduct of research in areas of mutual interest in social psychology.
- 504-505. CURRENT SOCIAL THEORY (3 each) Current contributions to social theory; their relations to each other and to the larger theoretical structure.
506. SEMINAR IN SOCIOLOGICAL THEORY (3-9)
507. INTRODUCTION TO GRADUATE STUDY IN SOCIOLOGY (1) Required of all incoming graduate students in sociology.
510. FIELD WORK IN SOCIOLOGY (1-6)
511. READINGS IN THE SOCIOLOGY OF HEALTH (1-6) Independent pursuit of existing knowledge in fields of the student's interest, in reference books, monographs, journals. Bibliography preparation. Prerequisite: Soc. 410.
512. SEMINAR IN DEVIANT BEHAVIOR (2-6) Advanced sociological study of crime, juvenile delinquency, mental disorders, suicide, drug addiction, prostitution, and other social deviation.
- 513-514. SOCIOLOGICAL METHODS (3 each) Critical review of methodological issues; philosophy of science; research designs; analysis and interpretation of findings.
515. SEMINAR IN COMMUNITY STUDIES (3)
523. SEMINAR IN POPULATION THEORY AND POLICY (1-6) Critical review of multidisciplinary population research with an emphasis on its relation to policy issues. Prerequisite: 3 credits in population or human ecology.
525. SEMINAR IN SOCIOLOGY (1-6) Research problems in theoretical and applied sociology.
530. RESEARCH ON MARRIAGE AND THE FAMILY (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.
- 532-533-534. SOCIAL RELATIONS (3 each) Critical appraisal of major social-psychological problems confronting modern man; emphasis on formulation of fruitful research projects and their evaluation.
535. SEMINAR IN GERONTOLOGY (2-6) A structural-functional analysis of current research dealing with the relationships between institutional structure, age grading, and social behavior.
546. SEMINAR IN POLITICAL SOCIOLOGY (3 per term, maximum of 6) Research and analysis of contemporary issues in political sociology.
551. COMPARATIVE INSTITUTIONS AND SYSTEMS OF STRATIFICATION (3) Critical appraisal of major problems in comparative sociology, including comparative studies of Western, socialist, and Third World countries.
555. INDUSTRIAL SOCIOLOGY (3) Research methods and techniques in industrial sociology; current research, unexplored areas.
- 572-573. SOCIAL STATISTICS (3 each) Application of parametric and nonparametric statistical methods to sociology; sampling; computer data processing techniques.
- 574-575. QUANTITATIVE SOCIOLOGY (3 each) Problems and issues in the mathematical and quantitative aspects of sociology.

- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

SOLID STATE SCIENCE (S S S)

ROBERT E. NEWNHAM, *In Charge of Graduate Programs in Solid State Science*
169 Materials Research Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barsch, Biggers, Cross, Dachille, Das, Fonash, Harrison, Henisch, Hummel, Kline, Knox, Macmillan, Madjid, McKinstry, Mulay, Newnham, D. Roy, R. Roy, Spear, Stubican, Thrower, Tressler, Tsong, Vastola, Vedam, Walker, and W. White.

Graduate Faculty: Associate Members Coleman, Johnson, McCarthy, Messier, and Painter.

The aim of this intercollege program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the necessary fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The program of courses taken by a student majoring in this program must necessarily cut across two or more disciplines. The relevant subject matter has been grouped into four areas: (1) the structure of solids (crystal chemistry and structure determination); (2) theory related to the solid state (physics, chemistry, and mechanics); (3) properties of solids (optical, electrical, magnetic, mechanical, thermal, and chemical); and (4) reactions of solids (phase equilibria, reaction mechanisms, reaction kinetics, and surface reactions).

The course work of all students will normally include the "core program" as periodically redefined. Recommended course sequences for each year for students with different undergraduate backgrounds are prepared by the chairman and are available from the student's adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages, or by one foreign language together with courses from other designated areas.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included in it mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. The applicant should be interested specifically in an interdisciplinary program of study and research. Thesis research on various aspects of the solid state may be conducted in the Materials Research Laboratory, the Applied Research Laboratory, or in appropriate departments in the Colleges of Earth and Mineral Sciences, Engineering, and Science. The experimental facilities for research in several aspects of materials science and engineering are exceptional.

S.S.S. 590 (Colloquium) and S.S.S. 596 (Individual Studies) will be offered once each year to promote the interdisciplinary aspects of solid state science. Further information will be available from the Solid State Science office.

In addition, students may select appropriate course work from any engineering or science department. The following list includes those which are most commonly taken to satisfy core curriculum requirements: Structure of Solids: Mat.Sc. 408, 512, 514. Solid State Chemistry: Mat.Sc. 416, 501, 503. Solid State Physics: Phys. 412, 413, 524, and Cer.Sc. 508.

SOLID STATE SCIENCE (S S S)

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

SPANISH (SPAN)

MARTIN S. STABB, *Head of the Department of Spanish, Italian, and Portuguese*
N-352 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Dalbor, Halsey, Lima, Lyday, Pérez, Stabb, Sturcken, and Triolo.

Graduate Faculty: Associate Members Fitz, Higgs, Peavler, Weiss, and Zamora.

The minimum requirement for admission will normally be 24 credits of post-intermediate work in Spanish language and literature. The department may waive the requirement of a thesis for M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPANISH (SPAN)

400. ADVANCED GRAMMAR AND COMPOSITION (3)

404. THE EVOLUTION OF SPANISH (3)

410. ADVANCED ORAL EXPRESSION AND COMMUNICATION (3)

413. THE TEACHING OF SPANISH (4)

414. SPANISH PHONOLOGY (3)

415. SPANISH MORPHOLOGY AND SYNTAX (3)

416. OLD SPANISH LITERATURE (3)

426. THE GOLDEN AGE (3)

427. DRAMA OF THE GOLDEN AGE (3)

439. DON QUIJOTE (3)

459. THE GENERATION OF 1898 (3)

472. THE CONTEMPORARY SPANISH AMERICAN NOVEL (3)

475. INTRODUCTION TO LATIN AMERICAN LITERATURE (3)

476. INTRODUCTION TO LATIN AMERICAN LITERATURE (3)

478. NATIONAL LITERATURE OF SELECTED HISPANIC COUNTRIES (3-9)

482. SPANISH LYRIC POETRY (3)

483. SPANISH DRAMA OF THE NINETEENTH CENTURY (3)

485. SPANISH DRAMA OF THE TWENTIETH CENTURY (3)

487. THE SPANISH NOVEL OF THE NINETEENTH CENTURY (3)

489. THE SPANISH NOVEL OF THE TWENTIETH CENTURY (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

499. FOREIGN STUDY IN SPANISH (3)

502. THEORY AND TECHNIQUES OF TEACHING SPANISH (1-3) Audio-lingual orientation. *Higgs*

503. METHODS AND BIBLIOGRAPHY IN SPANISH (1-3) Methods of research; evaluation of sources and materials.

505. OLD SPANISH: PHONOLOGY, MORPHOLOGY, AND SYNTAX (3) *Sturcken*
506. HISTORY OF THE SPANISH LANGUAGE (3) *Sturcken*
507. HISPANO-ROMANCE LINGUISTICS (3) *Sturcken*
510. SPANISH DESCRIPTIVE LINGUISTICS: PHONOLOGY (3) *Dalbor*
511. SPANISH TRANSFORMATIONAL-GENERATIVE LINGUISTICS (3) *Dalbor*
514. HISPANIC DIALECTOLOGY (3) Early fragmentation among the peninsular dialects; origins and descriptive analysis of the American dialects; Judeo-Spanish. *Dalbor and Sturcken*
516. MEDIEVAL SPANISH LITERATURE (3 per term, maximum of 9) Topics vary: *jugaría* and *clerecía*, emergence of lyric and brief narrative; history and didacticism; origins of novel; balladry; fifteenth-century innovations.
518. EL LIBRO DE BUEN AMOR (3) *Sturcken*
521. THE CELESTINA AND THE LITERATURE OF THE SPANISH PRE-RENAISSANCE (3) Chief trends and works of the period of the Catholic monarchs, with special emphasis on Fernando de Rojas' masterpiece *La Celestina*. *Pérez and Triolo*
526. SIXTEENTH-CENTURY SPANISH LITERATURE (3 per term, maximum of 9) Prose and poetry of major authors: works and trends of the Renaissance and the early Golden Age. *Pérez and Triolo*
528. SEVENTEENTH-CENTURY SPANISH LITERATURE (3 per term, maximum of 9) Prose and poetry of major authors: works and trends of the late Golden Age and Baroque period. *Pérez and Triolo*
538. THEATRE OF LOPE DE VEGA AND HIS CYCLE (3) Major works of Lope de Vega, Tirso de Molina, Guillén de Castro, Mira de Amescua, and others. *Pérez*
539. THEATRE OF CALDERÓN DE LA BARCA AND HIS CYCLE (3) Major works of Calderón de la Barca, Rojas Zorrilla, Agustín Moreto, and others. *Pérez*
540. CERVANTES (3 per term, maximum of 9) The literary works of Cervantes: *Don Quijote*, other novels, dramatic works, and poetry. *Pérez*
544. SPANISH ROMANTICISM (3) The major authors and works of peninsular romanticism, including poetry, drama and prose. *Halsey and Lima*
550. SPANISH REALISM (3) The major figures of the period with special emphasis on Pérez Galdós. *Zamora*
554. GENERATION OF 1898: PROSE (3) Selected essays and novels from the works of Ganivet, Pidal, Unamuno, Maeztu, Azorín, Lanza, Baroja and Valle-Inclán. *Lima and Zamora*
555. GENERATION OF 1898: POETRY AND DRAMA (3) Selected poems and plays from the works of Antonio and Manuel Machado, Benavente, Grau, Azorín, Valle-Inclán, Unamuno, Baroja and others. *Lima*
560. THE CONTEMPORARY NOVEL IN SPAIN (3) The novel since 1941: Cela, Laforet, Zunzunegui, Suárez Carreño, Matute, and others. *Zamora*
563. CONTEMPORARY DRAMA IN SPAIN (3) The drama from 1898 to the present day: Benavente, Valle-Inclán, García Lorca, Casona, Buero Vallejo, Sastre, and others. *Halsey and Lima*
566. CONTEMPORARY SPANISH POETRY (3) Various currents in Spanish poetry from the generation of 1927: Lorca, Aleixandre, Salinas, Guillén, Alonso, Alberti, Hernández, Otero and others. *Staff*
568. EARLY SPANISH AMERICAN LITERATURE (3 per term, maximum of 9) Content varies; selected topics from colonial period, romanticism, and the nineteenth century before modernism. *Staff*
570. MODERNISMO (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío. *Staff*
574. THE SPANISH AMERICAN NOVEL (3 per term, maximum of 9) Content varies; selected works from the late nineteenth century through the contemporary period. *Peavler*
575. THE SPANISH AMERICAN ESSAY (3) Tracing the history of ideas in Spanish America through major essayists. *Stabb*

576. TWENTIETH-CENTURY SPANISH AMERICAN POETRY (3) Influential poets and literary movements after *Modernismo*. *Lyday and Stabb*
577. SPANISH AMERICAN DRAMA (3) Dramatic literature in Spanish America from colonial times to the present. *Lyday*
581. THE SPANISH AMERICAN SHORT STORY (3) Critical analysis of the major writers and movements from Echeverría to the present. *Lyday, Peavler, and Stabb*
587. STYLISTIC AND LITERARY CRITICISM (3) Major theories of literary criticism applied to Hispanic literature.
588. SEMINAR IN HISPANIC LITERATURE (3-12) Common and individual research in special problems in Spanish or Spanish American literature.

SPEECH COMMUNICATION (SPCOM)

ROBERT S. BRUBAKER, *Head of the Department*
212 Sparks Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Brubaker, Cohen, Gilbert, Gregg, Holtzman, Paulson, Phillips, and White.

Graduate Faculty: Associate Members Barton, Benson, Butt, De Boer, Dunham, Hauser, Johnson, Pedersen, and Preston.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication, teaching of speech); speech science (voice, diction, phonetics, general semantics); and communicative theory. A thesis is required of all M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies without credit toward the graduate degree. Sp.Com. 400 and 502 are required of all graduate students who do not have their equivalents.

Students with a 3.00 junior-senior average, with scores on the Graduate Record Examination (general), and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPEECH COMMUNICATION (SPCOM)

*115G. ENGLISH AS A SECOND LANGUAGE (3-15) Development of communicative competence using spoken and written English. Intensive (full-time), intermediate, or advanced sections according to diagnostic test results. *Duque*

400. TEACHING OF SPEECH (3) *Butt and Pedersen*
402. SPEECH AND HUMAN BEHAVIOR (3) *Pedersen and Phillips*
403. INTERPERSONAL ORAL COMMUNICATION THEORY (3) *Phillips*
410. AMERICAN-ENGLISH PHONETICS (3) *Brubaker*
412. SPEECH CRITICISM (3) *Rosenfeld*

*No graduate credit is given for this course.

413. (Ling. 413) EXPERIMENTAL LINGUISTICS (3) *Brubaker*
 415. RHETORIC OF FILM AND TELEVISION (3) *Benson*
 417. DIRECTING FORENSICS (3) *Lutz*
 419. (Journ. 419) COMPARATIVE BROADCASTING SYSTEMS (3) *Barton*
 420. SYSTEMS AND THEORIES OF RHETORIC (3) *Hauser*
 425. RADIO PROGRAMMING AND PERFORMANCE (3) *Preston*
 431. ANATOMY AND PHYSIOLOGY OF THE VOCAL MECHANISMS (3) *Gilbert*
 435. RADIO AND TELEVISION PROGRAMMING (3) *Kaplan*
 437. TELEVISION PROGRAMMING AND PERFORMANCE (3) *Barton*
 440. SYSTEMS AND THEORIES OF HUMAN COMMUNICATION (3) *Craig*
 450. THEORY AND PRACTICE OF GROUP COMMUNICATION (3-6) *Cohen*
 455. GENDER ROLES IN COMMUNICATION (3) *Johnson*
 470. NONVERBAL COMMUNICATION (3-6) *Benson*
 475. PERSUASIVE CAMPAIGNS (3) *Benson*
 478. CONTEMPORARY AMERICAN POLITICAL RHETORIC (3) *Gregg*
 481. (L.A. 481) COMPUTER APPLICATIONS TO COMMUNICATIONS STUDIES (3) *Craig*
 485. ADVANCED ORAL INTERPRETATION OF LITERATURE (3) *Miller*
 487. (Journ. 487) MASS COMMUNICATIONS STUDY ABROAD (1-9) *Barton*
 490. PSYCHOLOGY OF SPEAKING AND LISTENING (3) *Holtzman*
 491. COMMUNICATION INTERNSHIP (1-9) *Preston*
 494. TEACHING OF ENGLISH AS A SECOND LANGUAGE (3) *Holtzman*
 495. DEVELOPMENT OF COMMUNICATION BEHAVIOR IN CHILDREN (3) *Butt*
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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500. SEMINAR IN AMERICAN ORATORY (2-6) History of American oratory with application of critical standards to the work of specific orators. *White*
 502. RESEARCH METHODS IN SPEECH (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech communication, clinical speech, or theatre arts.
 503. SEMINAR IN CRITICISM (3) Study of philosophies and methods available for the critical analysis of rhetorical transactions. Prerequisite: Sp.Com. 412. *Gregg*
 505. HISTORICAL DEVELOPMENT OF SPEECH THEORY AND CRITICISM (2-4) Classical theories of speech making from the earliest beginnings to the fall of the Roman Empire. *Hauser*
 506. HISTORICAL DEVELOPMENT OF SPEECH THEORY AND CRITICISM (2-4) Theories of speech making from the Renaissance to the present. *Cohen*
 507. CONTEMPORARY RHETORICAL THEORY (2-4) A study of rhetorical theory from 1930 to the present, focusing on semantic, political, sociological, symbolic, and philosophical perspectives. Prerequisites: Sp.Com. 412, 505 and/or 506. *Gregg and Hauser*
 508. SEMINAR IN BRITISH ORATORY (2-4) History of British oratory; application of critical standards to the work of selected orators. *Cohen*
 509. PROBLEMS IN RHETORIC AND ORATORY (2-6) Comparative study of selected orators and rhetoricians. Prerequisite: 6 credits in speech communication. *Rosenfield*
 510. PROBLEMS IN SPEECH EDUCATION (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisites: Sp.Com. 502 and 9 additional credits at the 400 or 500 level in speech communication, clinical speech, or theatre arts. *Phillips*
 520. SEMINAR IN SPEECH SCIENCE (3-6) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech communication, speech pathology and audiology, or psychology. *Brubaker and Gilbert*
 522. (S.P.A. 522) SPEECH PERCEPTION (3) Transformation of linguistic units into acoustic speech signals, theories of speech perception, and auditory processing of the speech signal. Prerequisites: Sp.Com. 410, 431, 520. *Gilbert*

530. **POLITICAL SPEAKING IN THE BROADCAST MEDIA (3)** Study and research of the principles of speaking as they are employed for political purposes when utilizing the broadcast media. *Barton*
540. **SEMINAR IN PROBLEMS OF TELEVISION AND RADIO (2-4)** Study and research in television and radio as they pertain to programming, production, relation to society, and speech. *Kaplan*
550. **SEMINAR IN ORAL PERSUASION (2-4)** Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech communication including Sp.Com. 200. *Holtzman*
552. **ORAL COMMUNICATION IN INDUSTRY, BUSINESS, AND GOVERNMENT (2-4)** Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communications skills. *Barton and Johnson*
554. **SEMINAR IN SMALL GROUP COMMUNICATION (2-4)** Communication variables in small groups. Experimental research and innovations in communication in vocational, therapeutic, and educational groups. *Phillips*
555. **SPEECH COMMUNICATION: PROBLEMS AND PRINCIPLES (2-6)** Prevalent theories of speech influence. *Phillips*
575. **RESEARCH PROBLEMS IN SPEECH (1-9)** Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech communication or speech pathology and audiology.
590. **COLLOQUIUM (1-3)**
597. **SPECIAL TOPICS (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

BRUCE M. SIEGENTHALER, *In Charge of Graduate Programs in Speech Pathology and Audiology*
110 Moore Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Frank, Frick, Gilbert, Michael, Moores, Siegenthaler, and Weiner.

Graduate Faculty: Associate Members Klevans and Volz.

Students may specialize in speech pathology, audiology, or education of the hearing impaired. The programs include the requirement of a number of field trips to diagnostic and treatment facilities and may include a period of internship at an off-campus location to be assigned by the staff. Students should expect to have moderate expenses related to these trips.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages. The nonthesis option is available for the M.S. degree.

Approximately 38 credits are required for admission, distributed among speech pathology, audiology, education of the hearing impaired, speech science, education, and psychology, and including a course in statistics. Students entering without an undergraduate program in the field may be required to take additional make-up work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Although occasionally admitted for the summer term, new master's students in the speech pathology option generally are admitted to the option only in the fall term.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

- 430. INTRODUCTION TO AUDIOLOGY (3)
- 433. VISUAL SPEECH RECEPTION AND AUDITORY TRAINING (3)
- 439. PRACTICUM IN AUDITORY TRAINING AND SPEECH READING (1-5)
- 440. (E.E.C. 440) SURVEY OF SPEECH AND HEARING DISORDERS (3)
- 442. SPEECH PATHOLOGY: ARTICULATION AND STUTTERING (3)
- 444. SPEECH PATHOLOGY: VOICE AND ORGANIC DISORDERS (3)
- 445. PROFESSIONAL PROGRAMS AND RELATIONSHIPS (3)
- 449. PRACTICUM IN SPEECH THERAPY (1-6)
- 459. PRINCIPLES OF CLINICAL MANAGEMENT IN S.P.A. (2)
- 460. COMMUNICATION SKILLS FOR HEARING IMPAIRED I (2)
- 461. COMMUNICATION SKILLS FOR HEARING IMPAIRED II (3)
- 462. CLINICAL BASES OF LANGUAGE DISORDERS (2)
- 463. TEACHING LANGUAGE TO THE HEARING IMPAIRED (3)
- 464-465. TEACHING SCHOOL SUBJECTS TO THE DEAF (2 each)
- 469. STUDENT TEACHING WITH THE DEAF (3-12)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 515. APPLICATION OF PHYSIOLOGICAL AND ACOUSTICAL CONCEPTS OF SPEECH PATHOLOGY AND AUDIOLOGY (4) Application of practical and theoretical concepts in neurology, physiology, and acoustics to communication disorders with implications for clinical therapy. Prerequisites: 6 credits in speech science and 6 credits in speech pathology and audiology.
- 516. APPLICATIONS OF PSYCHOLOGY OF SPEECH TO SPEECH PATHOLOGY AND AUDIOLOGY (1) Application of psychological concepts germane to theoretical and practical understanding of communication disorders; implications for clinical speech and language therapy. Prerequisites: 6 credits in speech pathology and audiology and 6 credits in psychology.
- 517. (Ling. 517) APPLICATIONS OF LINGUISTICS TO COMMUNICATION DISORDERS (1) Application of linguistic theory to the understanding of communication disorders, with clinical implications for speech and language therapy. Prerequisites: 12 credits in speech pathology and audiology, psychology, linguistics, or phonetics.
- 522. (Sp.Com. 522) SPEECH PERCEPTION (3) Transformation of linguistic units into acoustic speech signals, theories of speech perception, and auditory processing of the speech signal. Prerequisites: Sp.Com. 410, 431, 520.
- 530. SEMINAR IN AUDIOLOGY (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.
- 531. SPEECH AUDIOMETRY AND HEARING AIDS (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.
- 532. ACOUSTICAL INSTRUMENTS FOR HEARING (3) Acoustical instrumentation used for research in hearing, programs of hearing conservation, and noise control, including clinical and industrial applications. Prerequisite: 6 credits in acoustics, audiology, experimental psychology, or speech science at 400 level.
- 534. NOISE AND HEARING (3) Noise-induced hearing problems; interference with communication; annoyance and community problems caused by acoustic energy; regulations and standards. Prerequisite: 6 credits at the 400 level in acoustics, audiology, experimental psychology, or speech science.
- 535. PURE TONE AUDIOMETRY (3) Techniques, interpretation, and differential diagnosis of hearing ability by pure tone and related audiometric techniques. Prerequisites: S.P.A. 430, S.P.A. 433, Acs. 401; 6 credits in speech pathology and audiology.
- 538. PRACTICUM IN AUDIOLOGIC EVALUATION AND SELECTION OF HEARING AIDS (1-5) Prerequisite: S.P.A. 531.

539. **ADVANCED PRACTICUM IN EDUCATION OF THE DEAF (1-6)** Theoretical and clinical rationale of working with hearing impaired, professional role and relationships, therapy procedures, evaluation of process and outcomes. Prerequisite: S.P.A. 439.
540. **ARTICULATION DISABILITIES (3)** Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.
541. **THE VOICE AND ITS DISORDERS (3)** Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.
542. **STUTTERING (3)** Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.
543. **DIAGNOSTIC PROCEDURES IN CLINICAL SPEECH (3)** Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisite: S.P.A. 444.
544. **CLEFT PALATE (3)** Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.
545. **(E.E.C. 545) CEREBRAL PALSY (3)** Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multiprofessional habilitative program. Prerequisite: S.P.A. 444.
546. **LANGUAGE DISORDERS IN ADULTS (3)** Nature, etiology, diagnosis, and management of language disorders in adults. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.
547. **(E.E.C. 547) LANGUAGE DISORDERS IN CHILDREN (2)** Nature, etiology, diagnosis, and management of language disorders in children. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.
548. **PRACTICUM IN SPEECH DIAGNOSIS (1-3)** Supervised practice in interviewing, counseling, speech evaluation, and synthesis of psychological, medical, and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.
549. **ADVANCED PRACTICUM IN SPEECH THERAPY (1-6)** Theoretical and clinical rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.
550. **SEMINAR IN SPEECH PATHOLOGY (1-6)** Advanced study of special problems and new developments in speech pathology. Prerequisites: S.P.A. 442, 444.
560. **RECENT DEVELOPMENTS IN EDUCATION OF THE DEAF (2-6)** In-depth seminar-style study of communication disorders associated with deafness, and advanced and experimental attempts at remediation. Prerequisites: 8 credits in education of the deaf or audiology, S.P.A. 430 and 433, and 3 credits in child development or learning theory.
566. **EDUCATION AND GUIDANCE OF THE HEARING IMPAIRED (3)** Effects of hearing impairment on developmental, educational, social, and vocational adjustment; assisting the hearing impaired toward improved life adjustment. Prerequisites: S.P.A. 430, 433.
567. **AUDIOLOGY FOR HEARING AND SPEECH CLINICIANS (3)** Etiology, measurement, and differential diagnosis of hearing loss; overview of aural rehabilitation, including hearing aids and auditory training systems. Prerequisites: S.P.A. 430, S.P.A. 433; 6 credits in speech pathology and audiology.
596. **INDIVIDUAL STUDIES (1-6)**

STATISTICS (STAT)

WILLIAM L. HARKNESS, *Head of the Department*
219 Pond Laboratory

Degrees Conferred: Ph.D., M.S., M.A.

Graduate Faculty: Senior Members Antle, Bartoo, Haight, Harkness, Hettmansperger, Hultquist, and Patil.

Graduate Faculty: Associate Members Arnold, Boswell, Lynch, Rosenberger, and Ryan.

Graduate instruction and research opportunities are available in most areas of statistics and probability, including linear models, nonparametric statistics, robustness, statistical computing, analysis of count data, multivariate analysis, experimental design, reliability, stochastic processes and probability (applied and theoretical), distribution theory, and statistical ecology.

The opportunity is also available for students to gain practical experience by participating, for academic credit, in the department's consulting and collaborative research program.

For the M.A. degree the candidate must complete 30 course credits, with at least 18 credits (12 in statistics) of 500-level courses; 6 credits of mathematical statistics, Stat. 409 and 410; 3 credits in computer science, Math. 441 or 481; 3 credits in seminars and/or individual studies; and six credits in an approved area. In addition, the M.A. candidate must submit a master's paper. The requirements for the M.S. degree are the same as for the M.A., except that 6 credits of thesis research replace an equal number of course credits, and a thesis is required rather than a master's paper.

The department administers a master's and Ph.D. qualifying examination which all students in the program must take. Students are examined in two areas of their choice from mathematical statistics, applied statistics, and probability. This examination is intended to be taken early in the program and Ph.D. candidacy is contingent on successful completion of the examination.

After admission to candidacy, each Ph.D. candidate is required to pass two comprehensive examinations. One must be in mathematical statistics and the other in an area to be selected by the candidate, subject to the approval of the faculty. There is no foreign language requirement for the Ph.D. in Statistics. Every Ph.D. candidate is required to perform various services in addition to formal course work. If feasible, they all must gain teaching experience, be involved in statistical consulting (here at Penn State with other graduate students or non-Statistics faculty), and carry out research for the Ph.D. degree.

While applications from all students (including those who already have done graduate work) are reviewed, completion of a standard calculus sequence is regarded as a prerequisite. Students with a 3.00 or better junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

The department requires the verbal and quantitative scores on the Graduate Record Examination from those applicants who wish to be considered for financial support. The Graduate School requires all applicants for admission to submit the GRE scores.

Entering graduate students in Statistics for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. The results of this examination must be received by the Department of Statistics at least six months prior to the requested date of admission to the Graduate School.

Students in the Statistics program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 238).

STATISTICS (STAT)

- 401. EXPERIMENTAL METHODS I (3)
- 402. EXPERIMENTAL METHODS II (3)
- 409. (Math. 409) INTRODUCTION TO PROBABILITY THEORY (3)
- 410. (Math. 410) MATHEMATICAL STATISTICS I (3)
- 412. (Math. 412) MATHEMATICAL STATISTICS II (3)

418. (A.M. 418, Math. 418) DISCRETE PROBABILITY THEORY (3)
427. (Math. 427) DISCRETE STOCHASTIC MODELS (3)
451. INTRODUCTION TO APPLIED STATISTICS (3)
460. INTERMEDIATE STATISTICAL METHODS (3)
461. SAMPLING METHODS (3)
462. APPLIED REGRESSION ANALYSIS (3)
464. APPLIED NONPARAMETRIC STATISTICS (3)
480. INTRODUCTION TO STATISTICAL PROGRAM PACKAGES (1)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
501. REGRESSION ANALYSIS AND MODELING (3) Use of simple and multiple regression and correlation to analyze research data; dummy variables, step-wise and non-linear regression. Prerequisite: 6 credits in statistics or Stat. 451; matrix algebra.
502. ANALYSIS OF VARIANCE AND DESIGN OF EXPERIMENTS (3) Experimental design and analysis; fixed, mixed, and random effects models; covariance analysis; multiple comparisons; repeated measures; unbalanced data; computer techniques. Prerequisite: 6 credits in statistics.
503. DESIGN OF EXPERIMENTS (3) Design principles, optimality, confounding in: split plot, repeated measures, fractional factorial, response surface and balanced/partially balanced incomplete block designs.
504. ANALYSIS OF CATEGORICAL DATA (CONTINGENCY TABLES) (3) Classical analysis of multi-factor contingency tables; linear and log-linear models; measures of association; graphical methods. Prerequisites : 6 credits in statistics, matrix algebra.
505. APPLIED MULTIVARIATE STATISTICAL ANALYSIS (3) Analysis of multivariate data; T^2 -tests; partial correlation; discrimination; MANOVA; cluster analysis; regression; growth curves; factor analysis; principal components; canonical correlations. Prerequisite: 6 credits in statistics.
506. SAMPLING THEORY (3) Theory and application of sampling from finite populations. Prerequisite: 6 credits in statistics.
507. SEQUENTIAL ANALYSIS (3) A thorough discussion of sequential procedures of estimation and testing of hypotheses. Prerequisite: Stat. 410.
509. DISCRETE STATISTICAL MODELS AND METHODS (3) Systematic study of probability models and statistical methods pertaining to statistical analysis of data consisting of single and multiple counts. Prerequisite: Stat. 554.
510. APPLIED TIME SERIES ANALYSIS (3) Identification of models for empirical data collected over time. Use of models in forecasting. Prerequisite: Stat. 462 or 501.
512. (A.M. 512) INTRODUCTION TO STOCHASTIC PROCESSES (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. (Math.) 409 or Stat. (A.M., Math.) 418.
513. (A.M. 513) INTRODUCTION TO STOCHASTIC PROCESSES (3) Markov chains, random walks and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. (A.M.) 512.
- 517-518. (Math. 517-518) PROBABILITY THEORY (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.
524. ECOMETRICS (3) Stochastic models and statistical methods in ecological problems; population dynamics, spatial patterns in populations of one, two, or more species. Prerequisite: Stat. 409 or 418.
528. QUEUING MODELS IN TRANSPORTATION (3) Arrival patterns, the service mechanism, queue discipline, delays, multiple queues, problems involving interrupted flow, multiflow routes.
534. (M.E.R. 534) DYNAMIC PROGRAMMING (3) The study of the concepts underlying model-building and optimization of dynamic systems; applications to engineering, economic and environmental systems. Prerequisites: Stat. 418; I.E. 405 or Q.B.A. 451.

542. (Math. 542) **STATISTICAL DISTRIBUTION THEORY IN SCIENTIFIC WORK: I. DISCRETE MODELS** (3) Statistical distributions arising in scientific modeling and statistical inference; structures, interrelations, characterizations, and simulation with practical examples. Prerequisite: Stat. (Math.) 410; knowledge of matrix algebra.

543. (Math. 543) **STATISTICAL DISTRIBUTION THEORY IN SCIENTIFIC WORK: II. CONTINUOUS MODELS** (3) Statistical distributions arising in scientific modeling and statistical inference; structures, interrelations, characterizations, and simulation with practical examples. Prerequisite: Stat. (Math.) 542.

551. **LINEAR MODELS I** (3) Statistical distribution theory of quadratic forms and linear transformations; full-rank estimation; regression; response surfaces; Cochran's theorem. Prerequisites: Stat. 502; Math. 441 or 481.

552. **LINEAR MODELS II** (3) Non-full-rank statistical inference, interaction, variance components, covariance analysis, cross, hierarchal and incomplete classification theory and methodology. Prerequisite: Stat. 551.

558. **THEORY OF STOCHASTIC PROCESSES** (3) Stationary, independent, and orthogonal processes, discrete and continuous Markov processes, martingales and semi-martingales applications. Prerequisite: Stat. (Math.) 518.

559. (Math. 559) **THEORY OF STOCHASTIC PROCESSES** (3) Stationary, independent, and orthogonal processes, discrete and continuous Markov processes, martingales and semi-martingales applications. Prerequisite: Stat. (Math.) 518.

561. **STATISTICAL INFERENCE I** (3) Multiparameter estimation; linear estimation; maximum likelihood estimation; Bayesian estimation; large sample properties and procedures. Prerequisite: Stat. 410.

562. **STATISTICAL INFERENCE II** (3) Testing statistical composite hypotheses; invariance principles; Bayesian statistics; large sample properties and procedures. Prerequisite: Stat. 561.

564. **NONPARAMETRIC STATISTICS: THEORY** (3) Estimation and testing based on nonparametric procedures for location and regression models. Distribution theory and asymptotic efficiency. Prerequisites: Stat. 410 and 3 additional credits in statistics.

565. **THEORY OF MULTIVARIATE STATISTICAL ANALYSIS** (3) Multivariate normal, Wishart and related distribution; Hotelling's T^2 and Cochran's theorem; classification; growth curves; cluster analysis; factor analysis. Prerequisite or concurrent: Stat. 505. Prerequisites: Stat. 410; Math. 441 or 481.

572. **STATISTICAL DECISION THEORY I** (3) Structure of statistical games; optimal strategies, fixed sample-size games. Prerequisite: Stat. 410.

580. **STATISTICAL CONSULTING PRACTICUM** (2 per term, maximum of 10) General principles of statistical consulting and statistical consulting experience. Preparation of reports and other aspects of consulting. Prerequisites: Stat. 462 or 501; Stat. 502; Stat. 503 or 504 or 505.

590. **COLLOQUIUM** (1-3)

596. **INDIVIDUAL STUDIES** (1-6)

597. **SPECIAL TOPICS** (1-6)

TEACHING AND CURRICULUM (T & C)

ROBERT LESNIAK, *In Charge of the Graduate Program in Teaching and Curriculum*
The Capitol Campus, Middletown, PA 17057

Degree Conferred: M.Ed.

Graduate Faculty: Senior Members Allison, Lear, and Swetz.

Graduate Faculty: Associate Members Alexander, Ammon, Barnes, Chant, Eisenstein, Grella, Haber, Lesniak, Miller, Smith, Susskind, and Towns.

The Master of Education in Teaching and Curriculum at Capitol Campus provides to full-time and part-time students a curriculum designed to develop master teachers for public and private school instruction and to develop education specialists (teaching certification not required) for the areas of business, industry, government, medicine, and other social services. In addition, specialties are available in particular areas, such as: reading, urban education curriculum, early childhood education, elementary education and secondary English, social studies, and mathematics education.

Specifically, the goals of the program are to develop in students (1) the ability to communicate effectively either with school-aged students and their parents or with co-workers and/or clients; (2) the ability to conduct an instructional program which provides a sound intellectual and emotional climate for learning; (3) competence in a variety of teaching methods and in the utilization of materials and content appropriate for an effective instructional program; (4) the ability to interpret and to evaluate educational literature and research; and (5) the ability to describe and to evaluate major issues and current trends in instructional curriculum practice and development.

Certification programs are also available in the areas of Reading Specialist (K-12) and Private Nursery School Teachers. For graduates of education undergraduate programs, a total of 36 credits of work normally will be required. Graduates of undergraduate programs other than education normally will be expected to complete substantially more work to satisfy the requirements for this degree. Some of this additional work may include undergraduate courses. Program requirements include 3 credits in foundations of education; each student will be expected to complete from one-third to two-thirds of the work in courses other than education courses; and a minimum of 12 credits in 500-level courses must be completed. The last 12 credits in a student's program must be earned at the Capitol Campus. The application and transcript should be sent directly to the Graduate Office, The Capitol Campus, Middletown, PA 17057.

EDUCATION (ED)

505. CURRICULUM FOUNDATIONS (3) Study of the philosophical, cultural, social, and human developmental sources and implications of the school curriculum.

506. CURRICULUM DEVELOPMENT (3) Examination of theory, issues, organization, and local school problems of curriculum development.

520. SEMINAR IN JUNIOR COLLEGE TEACHING (3) The history of the two-year college, responsibilities of the teacher in the college organization, and methods of teaching.

541. THE ROLE OF THE COOPERATING TEACHER (3) A study of the responsibilities of classroom teachers who cooperate with teacher-preparation institutions. Prerequisite: teaching experience.

550. INTERNSHIP IN JUNIOR COLLEGE (3) Teaching humanities courses in a two-year college under a master teacher, who will direct, criticize, and evaluate the intern.

551. PROBLEMS IN TEACHING READING (3) A research-centered course in teaching reading. Prerequisite: Ed. 322, 451, 471, or 472.

552. PROBLEMS IN TEACHING LANGUAGE ARTS (3) A research-centered course in teaching language arts. Prerequisite: Ed. 416 or 452.

553. PROBLEMS IN TEACHING SOCIAL STUDIES (3) A research-centered course in teaching social studies. Prerequisite: Ed. 415 or 453.

554. PROBLEMS IN TEACHING SCIENCE (3) A research-centered course in teaching elementary science. Prerequisite: Sc. 454.

555. PROBLEMS IN TEACHING MATHEMATICS (3) A research-centered course in teaching mathematics. Prerequisite: Ed. 455.

560. CLASSROOM MANAGEMENT (3) Analysis of teaching styles, classroom behavior and interaction, organization and correlation of classroom activities and subject areas. (Requires practical application in an actual teaching situation.)

561. PSYCHOLOGY OF READING (3) Examination of the theoretical bases for reading which have direct practical implication for teaching reading. Prerequisites: Ed. 314, 451.

562. **LEARNING PROBLEMS IN A SCHOOL SETTING (3)** Investigation of surface behaviors and sources of stress in schools which hinder learning, and procedures for overcoming problems.
563. **ADVANCED METHODS IN TEACHING READING (3)** Advanced development of diagnostic and instructional techniques for teaching reading, with emphasis on individual and small group instruction. Prerequisite: Ed. 451.
564. **READING CLINIC (3-6)** A practicum course in which students display their competencies in working with children possessing reading problems. Prerequisite: Ed. 563.
571. **GREAT TEACHERS (3)** Study of one or more great teachers, e.g., Socrates, Comenius, Locke, Rousseau, Pestalozzi, Herbart, Froebel, Dewey, Kilpatrick.
572. **COMPARATIVE EDUCATION: WORLD PERSPECTIVES (3)** An evaluative comparison of American education with Western and non-Western educational systems.
585. **MASTER'S PRACTICUM (1-6)** The planning, implementation, and evaluation of an educational innovation in a classroom, or related learning activity.
586. **EDUCATIONAL RESEARCH DESIGNS (3)** Identification of research designs appropriate to educational field and laboratory investigations and the development of a master's paper proposal. Prerequisite: 15 credits of graduate study.
587. **MASTER'S PAPER (1-6)** Development of an original master's paper or creative production by the student, supervised by appropriate faculty and judged by a committee. Prerequisite: consent of adviser.
589. **PROBLEMS IN URBAN EDUCATION (4)** Independent study of selected topics related to urban education.
590. **COLLOQUIUM (1-3)**
591. **EDUCATION SEMINAR (1-6)** Seminars in important, and often controversial, topics in education.
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

THEATRE ARTS (THEA)

DOUGLAS N. COOK, *Head of the Department of Theatre and Film*
103 Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Members Allison, L. Manfull, and Walters.

Graduate Faculty: Associate Members Cook, Crocken, Duque, Firmin, Maddox, H. Manfull, Sabatine, A. Smith, and Stern.

This program emphasizes the study of the theatre with the following major objectives: (1) to help each graduate student attain skills and proficiencies in theatre arts; (2) to provide the training, discipline, and opportunities essential to the development of a professional ability in at least one area of the arts of the theatre; (3) to prepare students for active careers in academic, professional, and/or community theatre in a recognizably competitive job market; and (4) to assist students in acquiring discriminating taste and critical judgment in drama and theatre.

The Master of Arts degree program provides advanced training in the broad field of the theatre arts. It is designed to prepare the candidate for: (1) professional employment as a Theatre Arts teacher on the secondary or junior college level; (2) critical study and research particularly in preparation for the pursuit of a related doctorate or professional degree; and (3) related professional work in industry, business, or the arts. Two areas of study are required: general theatre (history, theory, criticism, dramatic literature, and research) and practical theatre (acting, directing, design, and technical theatre).

Requirements for admission to the M.A. program are:

1. A broad undergraduate preparation in theatre, including three credits each in acting, directing, stagecraft, and theatre history; and six credits of dramatic literature.
2. An undergraduate grade-point average of no less than 2.50 on a 4.00 scale.
3. Twelve credits in related subject areas such as oral interpretation, art, and music.
4. A vita and at least three letters of recommendation should be submitted.

The M.F.A. program is planned to provide a professional emphasis. Specialization in the following areas is stressed: performance (acting or directing); production (scene design, costuming, lighting, or technical direction); or playwriting. A required final project in the area of specialization includes a monograph. The program requires approximately nine terms to complete.

Requirements for admission to the M.F.A. program are:

1. Twenty-four credits in theatre arts, including one course each in acting, directing, and theatre crafts. Related courses in the student's area of specialization may be accepted.
2. All students are to submit evidence of ability in their areas of specialization under arrangements to be made with the department. Auditions, prompt books, portfolios, manuscripts, and other appropriate presentations are to be submitted by applicants to the various study programs.
3. A vita and letters of recommendation (at least three) are to be submitted.
4. Personal interviews should be arranged by all students.

All students in the M.A. and M.F.A. programs who are deficient in the required undergraduate courses may be requested to take additional course work in the areas of deficiency without degree credit.

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

All graduate majors are required to participate in University Theatre productions in positions of responsibility.

Theatre facilities are: the Playhouse, a proscenium-thrust theatre; the Pavilion, an arena or three-quarter theatre; theatre production studios for scenic, property, and costume preparation; rehearsal and dance studios; and a film laboratory with screening and editing facilities. Other University performance facilities include Schwab Auditorium, Kern Assembly Room, Music Concert Hall, and the Milton S. Eisenhower Auditorium with a seating capacity of 2,600. On the campus are several FM radio stations and WPSX, the University's educational TV station.

Related courses offered by other departments may be taken. Dramatic literature courses are available: Class. 411; C.Lit. 486, 487, 588; Engl. 438, 444, 445, 478, 488, 548, 549; Fr. 446, 461, 518, 534, 535, 567; Greek 421, 422. Design and technical courses are available in the Departments of Art, Art History, Engineering, Art Education, Architecture, Human Development, and Vocational Industrial Education. Courses in performance areas are available in the Departments of Music, Music Education, Physical Education, and Speech Communication.

THEATRE ARTS (THEA)

400. ADVANCED THEATRE AND FILM PROJECTS (1-6)
401. HISTORY OF ANCIENT AND MEDIEVAL THEATRE (3)
402. HISTORY OF RENAISSANCE AND ORIENTAL THEATRE (3)
403. HISTORY OF MODERN EUROPEAN AND BRITISH THEATRE (3)
405. HISTORY OF AMERICAN THEATRE (3)
409. FUNDAMENTALS OF CREATIVE PERFORMANCE FOR CLASSROOM TEACHERS (3)
410. CREATIVE DRAMATICS WITH CHILDREN (3)
411. PROJECTS IN CREATIVE DRAMATICS (2)
415. CHILDREN'S THEATRE ENSEMBLE (3 per term, maximum of 9)
416. STAGING THEATRE WITH CHILDREN (3)
417. EXPERIMENTAL TECHNIQUES IN CHILDREN'S THEATRE (3)
418. PUPPETRY (3)
420. ADVANCED VOICE AND DICTION FOR THE ACTOR (3 per term, maximum of 6)
421. DIALECTS FOR THE ACTOR (3 per term, maximum of 6)

422. PERFORMANCE FOR THE CAMERA (3)
423. TECHNIQUES AND STYLES OF THEATRE JAZZ DANCE (3 per term, maximum of 6)
424. DANCE FOR THE THEATRE (3)
425. DANCE FOR THE CONTEMPORARY MUSICAL THEATRE (2-6)
426. CHOREOGRAPHY FOR THE THEATRE (3 per term, maximum of 9)
427. THEATRE MAKEUP (2)
428. ADVANCED ACTING PROJECTS (1-9 per term, maximum of 9)
429. THEATRE PERFORMANCE PRACTICUM (1-6)
434. DIRECTING (3)
435. REHEARSAL METHODS FOR THE DIRECTOR (3)
436. CENTRAL STAGING (3)
437. DIRECTING FOR FILM AND TELEVISION (3)
445. ADVANCED PLAYWRITING (3-6)
446. ADVANCED SCREENWRITING (3-6)
450. ADVANCED SCENE DESIGN (3-6)
460. COSTUME DESIGN (3)
461. COSTUME CONSTRUCTION (3)
462. DRAFTING HISTORICAL COSTUMES FOR THE STAGE (3)
474. STAGE LIGHTING (3)
479. STAGE AND PRODUCTION MANAGEMENT (3)
485. SOUND FOR THEATRE PRODUCTION (3)
489. THEATRE PRODUCTION PRACTICUM (1-6 per term, maximum of 12)
490. ADVANCED FILM PRODUCTION (3 per term, maximum of 6)
491. AMERICAN FILMS (3)
492. FOREIGN FILM (3)
494. DOCUMENTARY IN FILM AND TELEVISION (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
499. ADVANCED FILM PRODUCTION PRACTICUM (1-12 per term, maximum of 12)
500. THEATRE RESEARCH: SOURCES AND PROCEDURE (3) Source materials and techniques as applied to theatre research; the form and content of theses and monographs.
503. THEATRE CRITICISM AND THEORY (3)
505. THEATRE HISTORY (3) Specific aspects of theatre from ancient times to the present.
522. ACTING I (4) Interpretation of theatrical styles: the tradition of tragedy; voice and movement.
523. ACTING II (4) Interpretation of theatrical styles: the tradition of comedy; voice and movement. Prerequisite: Thea. 522.
524. ACTING III (4) Interpretation of theatrical styles: forms of modern realism; voice and movement. Prerequisite: Thea. 523.
525. ACTING AND DIRECTING THEORY (3) The actor and director as related to cultural environment from the Greek theatre through the post-Stanislavskian theorists.
528. ADVANCED ACTING PROJECTS (3-9) Advanced performance projects for the second- and third-year M.F.A. actor who has completed all other performance courses.
530. PLAY INTERPRETATION FOR THE DIRECTOR (3) Theory and practice in the analysis and implementation of story, style, and form.
531. SPECIAL FORMS IN DIRECTING (3) Applied theory and techniques for various genres and periods of drama. Prerequisite: Thea. 530.
533. PROJECTS IN DIRECTING (1-6 per term)
535. EXPERIMENTAL THEATRE (1-3) Operational research and experimental methods in the preparation, planning, execution, observation, and evaluation of production.

- 540. **PLAYWRITING (3-6)** Focus on problems in writing the full-length script through seminar, play reading, and individual session.
- 543. **PROJECTS IN PLAYWRITING (1-9)** Preparation of the script for revision during and rewriting following production of the student's original play. Prerequisite: production approval.
- 553. **DESIGN AND TECHNICAL PRODUCTION (1-6 per term)** Special projects in design and technical execution of scenery, costumes, lighting, sound, and special effects.
- 560. **COSTUME DESIGN (1-6)** Design concepts, rendering, and execution of costumes for the stage.
- 574. **LIGHTING FOR THEATRE PRODUCTION (3)** Design techniques for production in arena, thrust, and proscenium theatre situations.
- 580. **THEATRE TECHNOLOGY (3)** Design consultation and specification of equipment, systems, and movable structures for new theatres; structures and projection devices for production.
- 582. **THEATRE ADMINISTRATION (3)** The theatre: organization and management.
- 583. **PROJECTS IN THEATRE ADMINISTRATION, MANAGEMENT, AND OPERATIONS (1-6)**
- 585. **THEATRE PLANNING (3)** Processes and problems in planning and designing theatres: performance, audience, and technical requirements.
- 590. **COLLOQUIUM (1-3)**
- 591. **SPECIAL PROBLEMS IN FILM AND TV (1-3 per term)**
- 596. **INDIVIDUAL STUDIES (1-6)**
- 597. **SPECIAL TOPICS (1-6)**

URBAN AND REGIONAL PLANNING (UR PL)

ROBERT A. SIMKO, *Head of the Program*
The Capitol Campus, Middletown, PA 17057

Degree Conferred: M.R.P.

Graduate Faculty: Senior Members Ferguson, Hand, and McDermott.

Graduate Faculty: Associate Members Buskirk and Simko.

The objective of this interdisciplinary program is to train professional planners who will be aware of the needs of citizens so that they can develop programs for sound social, political, economic, and cultural advancement through the enlightened management of all resources. The nonthesis option is available for this program.

For admission a student should have had at least one course each in economics, sociology or political science, geography or geology, graphics, and statistics. Students may be admitted with limited deficiencies but are required to remove the deficiencies early in the program without graduate degree credit. Applicants should submit scores on the Graduate Record Examination with their application. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered up to the number of spaces available. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

REGIONAL PLANNING (R PL)

- 400-401. **PRINCIPLES OF REGIONAL PLANNING (3-6)**
- 410. **PLANNING PROGRAMS (3)**
- 440. **PROBLEMS IN COMMUNITY AND REGIONAL PLANNING (1-9)**

501. **APPLIED METHODOLOGIES IN REGIONAL PLANNING (3)** Selected methodologies used in planning, including: demographic projections, simulations, network analyses, threshold analyses, allocation and location models. Prerequisite: R.Pl. 500.

502. **REGIONAL SYSTEMS ANALYSIS (3-6)** Spatial structure of regional and interregional systems. Theories of regional development. Spatial measures of location, density, central tendency and dispersion.
510. **PLANNING TECHNIQUES AND ANALYSIS I (3)** Regional socioeconomic structure, problems, and factors in planning; data collection, analysis, and implications.
520. **PLANNING TECHNIQUES AND ANALYSIS II (3)** Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.
530. **PLANNING TECHNIQUES AND ANALYSIS III (3)** Effects of political, cultural, and physical factors on planning.
540. **PROBLEMS IN REGIONAL PLANNING (1-9)** Planned individual projects involving library, laboratory (studio), or field work.
587. **MASTER'S PROJECT (1-6)** An original scholarly master's project initiated by the student, supervised by an appropriate professor, and judged by a committee.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

VETERINARY SCIENCE (V SC)

C. S. CARD, *Head of the Department*
115 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Card, Eberhart, Gentry, Massaro, Rothenbacher, Scholz, and Zarkower.

Graduate Faculty: Associate Members Ferguson, Griel, Patton, and Swope.

Graduate programs may be initiated with faculty specializing in areas of veterinary pathology, parasitology, toxicology, physiology, microbiology, and immunology. A thesis is required of candidates for both the M.S. and Ph.D. degrees.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one of several options including proficiency in reading a foreign language. Foreign students must show competence in English.

Prerequisite for admission is a bachelor's degree in an area of the life sciences or a veterinary degree. Adequate preparation in the basic sciences is required. Applicants with a 3.0 or better grade-point average and appropriate course backgrounds will be considered. Application for fall term admission must be completed by March 1 and must include GRE scores for the Aptitude Test and Advanced Biology Test.

VETERINARY SCIENCE (V SC)

405. **LABORATORY ANIMAL SCIENCE (3)** *Ferguson*
407. **DAIRY HERD HEALTH PROGRAMS (2)**
418. **METHODS OF ANIMAL CELL CULTURE (3)** *Patton*
420. **GENERAL ANIMAL PATHOLOGY (3)** *Rothenbacher*
496. **INDEPENDENT STUDIES (1-12)**
525. **MECHANISMS OF HYPERSENSITIVITY AND IMMUNOPATHOLOGY (3)** Concepts of hypersensitivity and special consideration of immunopathological conditions. Prerequisites: Biol. 437, Micrb. 410, and 3 credits of pathology. *Zarkower*

528. **DIAGNOSTIC PATHOLOGY (3-9)** Gross examination of animals and birds, their tissues and body fluids for pathologic changes. Prerequisites: 6 credits in pathology, microbiology, or infectious diseases.
535. **ACQUIRED AND CONGENITAL DISORDERS OF METABOLISM (3)** Abnormalities and alterations in metabolism due to dysfunctions of animal organs. Prerequisites: 6 credits in general biochemistry and 3 credits in animal physiology. *Scholz*
550. **EXPERIMENTAL ANIMAL SURGERY (3)** Principles of surgical preparation of experimental animal models for biological research, including aseptic procedures, anesthesia, surgical techniques, and aftercare. Prerequisites: Biol. 42, 421; V.Sc. 405. *Kavanaugh*
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

VOCATIONAL EDUCATION (VOCED)

TWYLA SHEAR, *In Charge of Graduate Programs in Vocational Education*
212 Rackley Building

Degrees Conferred: Ph.D., D.Ed.

Graduate Faculty: Senior Members Brantner, Curtis, East, Long, Love, Ray, Shear, Stinson, and Welch.

Graduate Faculty: Associate Members Anthony, Detwiler, Mortensen, Murray, Thal, Weis, and Williams.

This intercollege program emphasizes administration, research, teacher education and supervision, and curriculum development and design across program areas in vocational education.

A minimum of 45 credits is required in the major, to be divided among vocational education, general professional education, and social and behavioral science courses. A minor program of study is required for the D.Ed. degree and is optional for the Ph.D. degree, and may be developed within one of five social and behavioral science options, in general studies, or in other areas approved by the candidate's committee.

The communication and foreign language requirement for the Ph.D. degree may be satisfied from nine options, which include foreign languages, computer science, statistics, technical writing, and philosophic thought.

For admission, students must have a master's degree. Either the master's degree or the bachelor's degree must be in a vocational education specialization, or the applicant must have professional experience in vocational education.

Courses appropriate to these degrees taught in the three participating departments are: Ag.Ed. 418v, 420v, 422v, 424v, 426v, 434v, 501v, 502v, 508v, 509v, 520v, 521v, 524v, 530, 590v, 596v; I.Ed. 402v, 403v, 408v, 409v, 412v, 415v, 420v, 427v, 446v, 450v, 501v, 506v, 510v, 550v, 556v, 557v, 558v, 559v, 560v; H.E.Ed. 406v, 410v, 477v, 478v, 479v, 480v, 481v, 482v, 503v, 504v, 510v, 511v, 518v, 521v, 530v, 577v.

VOCATIONAL EDUCATION (VO ED)

- 413v. (E.E.C. 413) **VOCATIONAL EDUCATION FOR SPECIAL NEEDS LEARNERS (3)**
- 417v. (Cn.Ed. 417) **CAREER EDUCATION: ORIGINS, THEORY, IMPLEMENTATION (3)**
- 496v. **INDEPENDENT STUDIES (1-12)**
- 497v. **SPECIAL TOPICS (1-6)**

500v. **FOUNDATIONS OF VOCATIONAL EDUCATION (3)** Influence of legislative, economic, and social-psychological developments on the status and role of public vocational education in the United States.

508v. ADMINISTRATION OF VOCATIONAL EDUCATION (3) Concepts, strategies in administration of vocational programs in comprehensive high schools, area vocational technical schools, proprietary schools, and colleges.

530v. INTERNSHIP (1-10) Internship at cooperating school, governmental agency, or research institution, under supervision of graduate faculty. Prerequisites: admission to candidacy and completion of 15 credits in residence beyond master's degree.

590v. COLLOQUIUM (1-3)

596v. INDIVIDUAL STUDIES (1-6)

597v. SPECIAL TOPICS (1-6)

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

FREDERICK G. WELCH, *In Charge of Graduate Programs in Vocational Industrial Education*
119 Rackley Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Brantner, Long, and Welch.

Graduate Faculty: Associate Members Detwiler and Wircenski.

Emphasis may be placed upon preparation for teaching, supervision, administration, research, or teacher education. The primary focus of the program is preparation for entry into responsible positions within the broadly conceived field of vocational industrial education.

The communication and foreign language requirement for the Ph.D. degree may be met by the successful completion of selected courses in statistics and computer programming.

Persons admitted must have successfully completed a B.S. degree with a 2.50 grade-point average in vocational industrial education or fields related to vocational, safety, or technical education, or health occupations. Two years or more of experience in vocational industrial education, industrial training, military technical training, or work experience in an occupation related to vocational industrial education, vocational education, health occupations, safety education, or technical education are also required for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

INDUSTRIAL EDUCATION (I ED)

402v. SUPERVISION OF VOCATIONAL EDUCATION (3)

403v. SUPERVISED FIELD WORK (6)

408v. OCCUPATIONS (3)

409v. TESTS AND MEASUREMENTS (3)

415v. PROBLEMS IN COORDINATING VOCATIONAL EDUCATION (3)

427v. ADVANCED COURSE OF STUDY BUILDING (3)

446v. IMPROVEMENT OF INSTRUCTION IN VOCATIONAL EDUCATION (4)

450v. SHOP LAYOUT AND MANAGEMENT (3)

496v. INDEPENDENT STUDIES (1-12)

497v. SPECIAL TOPICS (1-6)

501v. SEMINAR IN VOCATIONAL EDUCATION (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. ADMINISTRATION OF VOCATIONAL EDUCATION (3) The job of the local director of industrial education in organizing and developing city and other local programs of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. VOCATIONAL EDUCATION FOR ADMINISTRATORS (3) Designed for school administrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. 1v or trade or teaching experience.

550v. RESEARCH IN VOCATIONAL EDUCATION (3) Research techniques in vocational industrial education.

556v. FEDERAL LEGISLATION (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

557v. PRESENT-DAY LOCAL, PERSONNEL, AND CURRICULUM PROBLEMS (2-3) Various plans, techniques, and practices.

558v. STATE AND LOCAL SUPERVISION AND ADMINISTRATION (2-3) The more important recent problems in organization, supervision, and administration.

559v. VOCATIONAL TECHNICAL EDUCATION (2-3) Problems of organization and administration of programs of technical education at the secondary and post-secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. PHILOSOPHY OF INDUSTRIAL EDUCATION (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

596v. INDIVIDUAL STUDIES (1-6)

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

WILDLIFE MANAGEMENT (W L M)

ROBERT S. BOND, *Director of the School of Forest Resources*
101 Ferguson Building

Degree Conferred: M.S., M.Agr.

Graduate Faculty: Senior Members George, Hutnik, Lindzey, Storm, and Ward.

Graduate Faculty: Associate Members Kelly, Rader, and Wakeley.

Programs are designed to give students an understanding of the biology and management of wildlife species and their environments, and include training in: wildlife ecology, nutrition, physiology, behavior, and pathology of a wildlife species or species groups; study of successional stages, land use, and management of various habitats and their impact on wildlife populations; population dynamics and manipulation of animal numbers; and studies of recreational, aesthetic, and socioeconomic values of wildlife. Most programs of study are strengthened by including appropriate courses offered by related departments. A thesis is required. The Ph.D. degree in forest resources allows specialization in wildlife ecology and management at the doctoral level (see Forest Resources).

The Master of Agriculture is intended to enable students to develop skills as professionals in the communication of technical knowledge. Candidates will elect a minimum of 15 credits of graduate-level courses in communication skills from courses in departments such as Agricultural Education, Instructional Media, Journalism, Recreation and Parks, Speech Communications, English, and Theatre. Any deficiencies in a student's resource specialty, as judged by his or her advisory committee, must be remedied. An acceptable paper on a selected professional problem or a report of internship training worth 3 credits or more is also required.

For admission, an applicant should have at least a 2.75 grade-point average, a 3.00 junior-senior average, and should have courses that are basic to the individual's field of specialization. Ordinarily these include 12 credits in communication, 12 credits in social sciences and humanities, 12 credits in quantification including calculus and statistics, 9 credits in physical sciences, 9 credits in biological sciences,

and 18 credits in forest products, forestry, wildlife, or related courses. Graduate Record Examination scores and three reference reports (forms supplied on request) and a brief statement describing the applicant's academic goals, career interests, and special qualifications are required. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to admission requirements may be made for students with special backgrounds, abilities, and interests.

WILDLIFE (WIDL)

- 408. MAMMALOGY (3)
- 427. RANGE ECOLOGY AND MANAGEMENT (3)
- 430. WILDLIFE ECOSYSTEMS (3)
- 446. WILDLIFE ECOLOGY (3)
- 447. WILDLIFE MANAGEMENT (3)
- 492. FIELD RESEARCH TECHNIQUES (3)
- 493. LABORATORY TECHNIQUES IN WILDLIFE RESEARCH (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 547. WILDLIFE MANAGEMENT (3) Management, maintenance, and manipulation of wildlife populations and habitat. Prerequisite: Wildl. 447.
- 551. WILDLIFE BIOMETRICS AND POPULATION ANALYSIS (3) Application of biometrics and mathematics to concepts and problems in wildlife ecology with emphasis on population analysis. Prerequisites: 3 credits in animal ecology and 6 credits in biometrics or statistics.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2)

ZOOLOGY (ZOO)

E. S. LINDSTROM, *Head of the Department of Biology*
208 Erwin W. Mueller Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cooper, Dunson, Hibbard, Hollis, MacCluer, Wickersham, and Williams.

Graduate Faculty: Associate Members Arnold, Beatty, Mitchell, Neff, Pearson, Petters, Reimer, Rheuben, and Turpen.

This program offers emphasis in animal behavior, cell biology, developmental biology, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, morphology, physiology, or population dynamics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Admission is restricted to students who have a baccalaureate degree in a biological science with emphasis on zoological subjects and adequate preparation in mathematics and the physical sciences. A cumulative undergraduate average of at least 3.00 is required. Each applicant must provide scores from the Graduate Record Examination, letters from two persons who are familiar with the student's academic competence, and a personal statement of interests and objectives.

NOTE: *For courses in Zoology and related subjects see Biology, Genetics, and Physiology.*

OTHER GRADUATE COURSES

The following courses are in fields in which neither graduate major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department head or program chairman, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400-series courses in degree programs apply to these courses.

ADMINISTRATION OF JUSTICE (ADM J)

- 401. PROBATION, PAROLE, AND PARDONS (3)
- 410. CORRECTIONAL COUNSELING PROCESSES (3)
- 420. SPECIAL OFFENDER TYPES (3-6)
- 430. CORRECTIONAL INSTITUTIONS AND SERVICES (3)
- 440. FUNDAMENTAL TECHNIQUES OF SCIENTIFIC CRIMINAL INVESTIGATION (3)
- 441. THE JUVENILE JUSTICE SYSTEM (3)
- 460. HISTORY AND FUNCTION OF CRIMINAL JUSTICE COMPONENTS (3)
- 470. LAW OF CRIMES AND CORRECTIONS (3)
- 471. LEGAL RIGHTS, DUTIES, LIABILITIES OF CRIMINAL JUSTICE PERSONNEL (3)
- 472. CRIME AND THE AMERICAN COURT SYSTEM (3)
- 482. SEMINAR, CRIMINAL JUSTICE AGENCY ADMINISTRATION (3)
- 490. ADVANCED FIELD WORK IN ADMINISTRATION OF JUSTICE (4)
- 491. FIELD WORK IN ADMINISTRATION OF JUSTICE (2)
- 492. PROFESSIONAL FIELD THESIS IN ADMINISTRATION OF JUSTICE (4)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

AGRICULTURE, GENERAL (AG)

- 400. INTRODUCTORY BIOMETRY (3)
- 430. INTERNSHIP (1-10)

AMERICAN STUDIES (AM ST)

- 402. SEMINAR IN AMERICAN STUDIES (3-9)
- 405. ETHNICITY AND THE AMERICAN EXPERIENCE (3)
- 501. THEORY AND METHODS OF AMERICAN STUDIES (3) Theory and methods for the analysis of American culture: history of ideas, analysis of myth and symbol, comparative arts, etc.
- 502. PROBLEMS IN AMERICAN STUDIES (3-6) A variable-content course, addressed each term to a specific problem, topic, or period in American culture.
- 596. INDIVIDUAL STUDIES (1-6)

ANIMAL SCIENCE (AN SC)

- 422. QUANTITATIVE INHERITANCE AND ANIMAL BREEDING (3)
- 455. ANIMAL GENETICS (2)

APPLIED MATHEMATICS (A M)

- 417. (Math. 417) TENSOR ANALYSIS (3)
- 418. (Math., Stat. 418) DISCRETE PROBABILITY THEORY (3)
- 419. (Math., Phys. 419) THEORETICAL MECHANICS (3)
- 431. (Math. 431) ORDINARY DIFFERENTIAL EQUATIONS (3)
- 432. (Math. 432) FOURIER SERIES AND PARTIAL DIFFERENTIAL EQUATIONS (3)

433. (Math. 433) OPERATIONAL MATHEMATICS (3)
441. (Math. 441) MATRIX ALGEBRA (3)
451. (Math. 451) ADVANCED CALCULUS FOR ENGINEERS I: REAL VARIABLES (3)
452. (Math. 452) ADVANCED CALCULUS FOR ENGINEERS II: COMPLEX ANALYSIS (3)
461. (Math., Phys. 461) THEORETICAL MECHANICS (3)
496. INDEPENDENT STUDIES (1-12)
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504. (Math. 504) OPTIMIZATION THEORY (3) Least squares problems, min-max game theory, global theory of constrained optimization, iterative methods of optimization. Prerequisite: Math. 420.
505. (Math. 505) INTEGRAL EQUATIONS (3) Fredholm and Volterra equations, and applications. Prerequisite: A.M. (Math.) 431 or 432 or Math. 420.
506. (Math. 506) DISTRIBUTIONS AND GENERALIZED FUNCTIONS (3) Schwartz-Sobolev theory of distributions, tempered distributions, Fourier transforms, fundamental solutions of ordinary and partial differential equations; applications. Prerequisite: A.M. (Math.) 431 or 432 or Math. 420.
507. (Math. 507) CALCULUS OF VARIATIONS AND OPTIMAL CONTROL (3) Classical and modern theory of the calculus of variations; problems in optimal control. Prerequisite: A.M. (Math.) 431 or 432 or Math. 420.
512. (Stat. 512) INTRODUCTION TO STOCHASTIC PROCESSES (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. 409 or A.M. (Stat., Math.) 418.
513. (Stat. 513) INTRODUCTION TO STOCHASTIC PROCESSES (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: A.M. (Stat.) 512.
515. (Math. 515) PARTIAL DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations with reference to physical applications. Prerequisite: A.M. (Math.) 431 or 432.
516. (Math. 516) ADVANCED PARTIAL DIFFERENTIAL EQUATIONS (3) Elliptic operators, fundamental solutions, weak and strong derivatives, Sobolev inequalities, Dirichlet problem, equations of evolution, semi-groups. Prerequisite: A.M. (Math.) 515.
- 560-561. (Math. 560-561) ORDINARY DIFFERENTIAL EQUATIONS (3 each) Linear spaces and operators, existence and uniqueness of solutions, linear systems, Green's functions, eigenvalue problems—including Fourier series. Prerequisite: Math. 72 or 250 or 383 or A.M. (Math.) 431.
573. SPECIAL TOPICS (2-12) Various topics according to instructor and students. Prerequisite: second-year graduate standing.

THE ARTS (ARTS)

400. CONTEMPORARY FORMS IN THE ARTS (3)
496. INDEPENDENT STUDIES (1-12)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

BEHAVIORAL SCIENCE (BEHSC)

410. BIOSTATISTICS (2)
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501. BEHAVIORAL SCIENCE (3) Integration of biopsychosocial substrates of behavior, variability in behavior, growth and development, and behavioral correlates of disease and health.
502. BEHAVIORAL SCIENCE (2) Continued integration of biopsychosocial substrates with emphasis on adaptation, growth and development, and behavioral correlates of disease and health.
503. HEALTH BEHAVIOR AND HUMAN ECOLOGY (3) Behavioral substrates with emphasis on health behavior, human ecology, stress, behavioral factors in disease, society, prevention, and health systems. Prerequisite: Beh.Sc. 502.

511. **MEDICAL STATISTICS AND RESEARCH DESIGN (2)** Use of theoretical and applied statistics in medical research design and in the interpretation of data.
531. **BEHAVIORAL AND PHYSIOLOGICAL CORRELATES OF STRESS (3)** Effects of stress on all physiological processes; role of learning, cognition, personality, and culture in adapting to stress.
533. **BIOFEEDBACK AND THE CONTROL OF INTERNAL RESPONSES (2)** Discusses theoretical and clinical applications of voluntary control over EEG, cardiovascular and muscle activity, body temperature, and other physiological processes.
535. **NERVOUS SYSTEMS AND BEHAVIOR (3)** Synthesis of behavioral science, neurobiology, and physiology with emphasis on integrative functions of peripheral, central, and autonomic nervous systems.
537. **MECHANISMS OF MEMORY (2)** Discussion of physiological mechanisms involved in information storage and retrieval. Experimental design in memory research is emphasized.
551. **HEALTH, ILLNESS, AND CULTURE (3)** A medical sociology seminar devoted to the socio-cultural aspects of health and sickness.
555. **BEHAVIOR CHANGE (3)** Review of behavioral science research and theory relevant for behavior change procedures used in medicine.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

BIOLOGICAL HEALTH (B H)

401. **BEHAVIORAL CONCEPTS AND HEALTH INTERVENTION (3)**
496. **INDEPENDENT STUDIES (1-12)**
497. **SPECIAL TOPICS (1-6)**

BLACK STUDIES

Students who wish to take courses in black studies may select from the following: Anthy. 424, 447; Com.D. 407, 419; C.Lit. 422, 423; C.F.Ed. 466; Econ. 424, 461; Fr. 458; Geog. 444; Hist. 459, 477, 478; Pl.Sc. 453, 454; Soc. 415, 419.

BUSINESS EDUCATION (BUSED)

575. **ADMINISTRATION AND SUPERVISION IN BUSINESS EDUCATION (3)** Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.
576. **INTRODUCTION TO RESEARCH IN BUSINESS EDUCATION (3)** Methods of research in business education; opportunity to compile annotated bibliographies on current problems; analysis and evaluation of significant research.
577. **EVALUATION OF RESEARCH AND EMPIRICAL LITERATURE IN BUSINESS EDUCATION (3)** Application of evaluation methods to current literature in business education; special attention to research studies. Prerequisite: Bus.Ed. 576.
578. **SEMINAR IN BUSINESS EDUCATION (1-6)** Intended for graduate students preparing theses or final documents, or for those working on special studies in business education. Prerequisite: Bus.Ed. 577.

CHINESE (CHNS)

496. **INDEPENDENT STUDIES (1-12)**
497. **SPECIAL TOPICS (1-6)**

COMMUNITY DEVELOPMENT (COM D)

- 402. POLITICS, POLICY, AND COMMUNITY ACTION (3)
- 404. COMMUNITY DEVELOPMENT THROUGH PLANNED CHANGE (3)
- 405. COMMUNITY MENTAL HEALTH: AN ECOLOGICAL APPROACH TO HUMAN SERVICES (3)
- 407. COMMUNITY CONFLICT THEORY (3)
- 417. IDENTIFYING COMMUNITY POWER STRUCTURES (3)
- 419. COMPARATIVE COMMUNITY DEVELOPMENT (3)
- 421. AGING AND SOCIAL POLICY (3)
- 433. PLANNING OF COMMUNITY SERVICE PROGRAMS (3)
- 434. EVALUATION OF COMMUNITY SERVICE PROGRAMS (3)
- 435. COST-EFFECTIVENESS ASSESSMENT OF COMMUNITY SERVICE PROGRAMS (3)
- 450. COMMUNITY SERVICES STUDIO (1-6)
- 490. ADVANCED FIELD WORK (4)
- 491. SEMINAR — FIELD WORK IN COMMUNITY DEVELOPMENT (2)
- 492. RESEARCH IN FIELD WORK (4)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

CULTURAL FOUNDATIONS OF EDUCATION (CF ED)

- 415. (Anthy. 415) ANTHROPOLOGY OF EDUCATION (3)
 - 416. (Soc. 416) SOCIOLOGY OF EDUCATION (3)
 - 417. PHILOSOPHIC BASIS OF EDUCATION (3)
 - 418. HISTORY OF EDUCATION IN THE UNITED STATES (2-3)
 - 419. HISTORY OF EDUCATION IN ANCIENT AND MEDIEVAL TIMES (3)
 - 420. HISTORY OF MODERN EUROPEAN EDUCATION (3)
 - 422. INTRODUCTION TO COMPARATIVE EDUCATION (3)
 - 425. EDUCATION IN AFRICA (3)
 - 466. RACE, POVERTY, AND THE SCHOOLS (3)
515. EXPERIMENTALIST PHILOSOPHIES OF EDUCATION (2-3) John Dewey's educational philosophy and later formulations by Bode, Kilpatrick, Childs, Brameld, and others. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.
516. TOPICAL SEMINAR ON SCHOOL AND SOCIETY (2-6) An intensive and comprehensive analysis of one selected aspect of the relationship of educational institutions to their societal setting. Prerequisite: C.F.Ed. 416.
517. EXISTENTIAL PHILOSOPHY OF EDUCATION (3) The nature, aim, organization, policy, and process of education examined from the viewpoint of existential philosophy and existential phenomenology. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy at the 400 level or above.
519. CONTEMPORARY PHILOSOPHIES OF EDUCATION (2-3) Implications for education of various types of realism, idealism, existentialism, and analytic philosophy. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.
521. EDUCATION IN THE LATIN-AMERICAN COUNTRIES (2-3) Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina. Prerequisite: C.F.Ed. 422 or 6 credits in Latin-American studies.
522. COMPARATIVE EUROPEAN EDUCATION (2-3) Educational policies and practices in school systems in western and central European nations. Prerequisite: C.F.Ed. 422.
524. EDUCATION IN COMMUNIST COUNTRIES (2-3) Educational policies and practices in Soviet Russia and other Communist countries. Prerequisite: C.F.Ed. 422 or 6 credits in Russian or Asian studies.
526. EDUCATION IN DEVELOPING COUNTRIES (2-3) Educational problems and trends in selected countries, with particular reference to Africa, the Middle East, and Southeast Asia. Prerequisite: C.F.Ed. 422 or 6 credits in Asian, African, or Latin-American studies.

532. SOCIAL CHANGE, CULTURAL DYNAMICS, AND EDUCATION (2-3) The social role of the school in a rapidly changing society. Prerequisite: C.F.Ed. 416.

534. READINGS IN PHILOSOPHY OF EDUCATION (1-6) Selected philosophic writings — classic, modern, or contemporary — on education. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

536. EDUCATIONAL LEADERS AND CLASSICS (2-3) Selected leaders and their writings, with emphasis on historical-social context, including Quintilian, Erasmus, Comenius, Fénelon, Pestalozzi, and Mann.

592. SEMINAR IN CULTURAL FOUNDATIONS OF EDUCATION (1-9) Conferences and discussions designed to meet the need for special study of particular areas in cultural foundations of education. Prerequisites: 12 credits of graduate work in cultural foundations of education.

EARTH AND MINERAL SCIENCES (EM SC)

420. (S.T.S. 420) ENERGY AND MODERN SOCIETY (3)

421. (S.T.S. 421) MATERIALS AND MODERN SOCIETY (3)

596. INDIVIDUAL STUDIES (1-6)

EAST ASIAN STUDIES (EA ST)

401. EAST ASIAN STUDIES (3-6)

ENGINEERING (ENGR)

410. (S.T.S. 410) TECHNOLOGY: ITS CHARACTER, ROLE, AND FUNCTION (3)

450. PATENT FUNDAMENTALS (3)

500. SPECIAL TOPICS IN ENGINEERING (1-3)

ENVIRONMENTAL RESOURCE MANAGEMENT (E R M)

400. SENIOR SEMINAR (1)

410. POLLUTION OF ENVIRONMENTAL SYSTEMS (3)

411. LEGAL ASPECTS OF RESOURCE MANAGEMENT (3)

412. RESOURCE SYSTEMS ANALYSIS (3)

413. CASE STUDIES IN ECOSYSTEM MANAGEMENT (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

FOLKLORE (FOLK)

400. THEORY AND TECHNIQUES OF FOLKLORE (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

GERONTOLOGY

In several programs students may select gerontology or adult development and aging as an area of specialization — in the behavioral and social sciences, in the biological sciences, and in certain professional programs. No major or degree in gerontology is offered. Information may be obtained from the Gerontology Center, S-211 Henderson Human Development Building.

HEALTH PLANNING AND ADMINISTRATION (H P A)

- 410. PRINCIPLES OF PUBLIC HEALTH ADMINISTRATION (3)
- 420. ENVIRONMENTAL HEALTH (3-6)
- 430. PRINCIPLES OF HEALTH PLANNING (3)
- 431. HEALTH PLANNING METHODS (3)
- 432. HEALTH SYSTEMS MANAGEMENT (3)
- 433. HEALTH SYSTEMS THEORY (3)
- 440. EPIDEMIOLOGIC BASIS FOR PLANNING (3)
- 445. (Econ. 445) HEALTH ECONOMICS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

HUMAN DEVELOPMENT (H DEV)

- 401. PROFESSIONAL ISSUES IN HUMAN DEVELOPMENT (1-3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 499. SENIOR THESIS (1-10)

516. METHODS OF RESEARCH IN HUMAN DEVELOPMENT (1-6) Review of problems and techniques of research in human development.

517. MULTIVARIATE STUDY OF CHANGE AND HUMAN DEVELOPMENT (3) Models of development and change derived from empirical research utilizing multivariate research design and procedures. Prerequisites: at least three statistics courses, including correlation and regression analysis.

HUMANITIES (HUMAN)

- 471. HUMANISTIC STUDIES (1-4)
- 490. (C.&S. 490) HUMANITIES FOR TEACHERS (3)

INTERDISCIPLINARY PROGRAM IN THE HUMANITIES

Qualified students who wish to receive a Ph.D. degree in one of the graduate major programs in the College of the Liberal Arts or the College of Arts and Architecture, and yet would like to receive an interdisciplinary education, may enter the interdisciplinary program in the humanities after they have been properly enrolled in one of the major programs, provided their interdisciplinary interest lies within the realm of the humanities.

INTERNATIONAL UNDERSTANDING (INT U)

- 400. WORLD AFFAIRS AND INTERNATIONAL UNDERSTANDING (3- 6)

ITALIAN (IT)

- 415. DANTE (3)
- 420. PETRARCA AND BOCCACCIO (3)
- 425. THE LITERATURE OF THE ITALIAN RENAISSANCE 7(3)
- 450. NINETEENTH-CENTURY ITALIAN LITERATURE (3)
- 460. TWENTIETH-CENTURY ITALIAN LITERATURE (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

588. SEMINAR IN ITALIAN LITERATURE (3-12) Common and individual research in special problems.

JAPANESE (JAPNS)

- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

LABOR STUDIES (L S)

- 400. COMPARATIVE INDUSTRIAL RELATIONS SYSTEMS (3)
 - 404. COLLECTIVE BARGAINING TRENDS (3)
 - 411. TRADE UNION ADMINISTRATION (3)
 - 413. (Econ. 413) COMPARATIVE LABOR MOVEMENTS (3)
 - 414. (Econ. 414) THEORIES OF THE LABOR MOVEMENT (3)
 - 433. (Pl.Sc. 433) THE LAW OF LABOR-MANAGEMENT RELATIONS (3)
 - 435. LABOR RELATIONS IN THE PUBLIC SECTOR (3)
 - 437. IMPASSE RESOLUTION IN LABOR RELATIONS (3)
 - 454. (Soc. 454) INDUSTRY AND THE COMMUNITY (3)
 - 455. (Soc. 455) THE SOCIOLOGY OF WORK (3)
 - 458. (Hist. 458) HISTORY OF AMERICAN ORGANIZED LABOR SINCE 1877 (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
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- 596. INDIVIDUAL STUDIES (1-6)
 - 597. SPECIAL TOPICS (1-6)

LANDSCAPE ARCHITECTURE (LARCH)

- 431. LANDSCAPE DESIGN — AREA ANALYSIS (3)
- 432. LANDSCAPE DESIGN — SITE ANALYSIS (3)
- 433. LANDSCAPE DESIGN — DETAIL ANALYSIS (3)
- 434. PARK FACILITY PLANNING AND EVALUATION (3)
- 435. LANDSCAPE CONSTRUCTION MATERIALS (3)
- 437. BASIC LANDSCAPE CONSTRUCTION (3)
- 439. ADVANCED LANDSCAPE CONSTRUCTION (3)
- 441. LANDSCAPE DESIGN — DETAIL DESIGN (3)
- 442. LANDSCAPE DESIGN — AREA DESIGN (3)
- 443. LANDSCAPE DESIGN — SITE DESIGN (3)
- 444. LANDSCAPE ARCHITECTURE FIELD TRIP (1)
- 451. COMPREHENSIVE LANDSCAPE DESIGN I (4)
- 452. COMPREHENSIVE LANDSCAPE DESIGN II (4)
- 453. COMPREHENSIVE LANDSCAPE DESIGN III (4)
- 457. PROFESSIONAL PRACTICE (2)
- 458. ADVANCED LANDSCAPE COMMUNICATIONS (2)
- 471. PARK PLANNING THEORY AND CONCEPTS (2)
- 472. PLANNING AND PUBLIC POLICY (3)
- 473. RECREATION RESOURCE PLANNING (3)
- 474. SITE ENGINEERING FUNDAMENTALS (1)
- 475. PARK SYSTEMS PRACTICUM (1)
- 491. LANDSCAPE SEMINAR I (1)
- 492. LANDSCAPE SEMINAR II (1)
- 493. LANDSCAPE SEMINAR III (1)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 499. FIELD EXPERIENCE (1-3)

518. **ADVANCED PROBLEMS IN LANDSCAPE DESIGN (2-12)** Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects.
521. **TECHNICAL LANDSCAPE ARCHITECTURAL PRACTICES (2-12)** Specific technical and professional problems in landscape architectural planning and practice.

LIBERAL ARTS (L A)

460. UNDERGRADUATE INTERNSHIP (1-6)
461. ACADEMIC ADVISER TRAINING (1)
470. UNDERGRADUATE FIELD EXPERIENCE OR PRACTICUM (1-12)
480. (S.T.S. 480) TECHNOLOGICAL CHANGE AND HUMAN VALUES (3)
481. (Sp.Com. 481) COMPUTER APPLICATIONS TO COMMUNICATION STUDIES (3)
482. QUANTITATIVE METHODS FOR HUMANISTS I (3)
483. QUANTITATIVE METHODS FOR HUMANISTS II (3)
484. (Engl. 484) COMPUTATIONAL AND QUANTITATIVE STYLISTICS (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

LITHUANIAN (LITH)

500. **STRUCTURE OF LITHUANIAN (3)** Analysis of the phonology, morphology, and syntax of Lithuanian; comparative linguistic study of Balto-Slavic and Indo-European. Prerequisite: one graduate course in linguistics.

MATERIALS SCIENCE (MATSC)

401. MATERIALS SCIENCE FOR TEACHERS I (3)
404. PROCESS MEASUREMENT AND CONTROL (1-3)
406. INTRODUCTION TO BIOMEDICAL MATERIALS (3)
408. (Geosc. 408) X-RAY DIFFRACTION (3)
411. (Geosc. 411) INSTRUMENTAL TECHNIQUES APPLIED TO MATERIALS AND MINERAL SCIENCE PROBLEMS (1-6)
- Unit A. X-RAY DIFFRACTION
- Unit B. TRANSMISSION ELECTRON MICROSCOPY
- Unit C. SPECTROSCOPY
- Unit D. ELECTRON MICROPROBE ANALYSIS
- Unit E. SCANNING ELECTRON MICROSCOPY
- Unit F. ABSORPTION SPECTROSCOPY
- Unit G. ION BEAM TECHNIQUES
412. QUANTITATIVE MICROSTRUCTURAL AND PARTICULATE CHARACTERIZATION (1)
416. MATERIALS PREPARATION (2)
420. MATHEMATICAL MODELING FOR MATERIALS SCIENTISTS (3)
490. SPECIAL TOPICS IN MATERIALS SCIENCE (1-9)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
501. **THERMODYNAMICS OF MATERIALS (3)** Application of thermodynamics to materials equilibria and processes, including solution theory, electrochemical processes, capillarity, and the effect of stresses. Prerequisite: Chem. 451.
503. (G.M. 503) **KINETICS OF MATERIALS PROCESSES (3)** Introduction to application of transition state theory and mass transfer to the kinetics of materials and mineral processes. Prerequisites: Math. 100; Chem. 451; Mat.Sc. 501 or G.M. 521.
512. (G.M. 512) **PRINCIPLES OF CRYSTAL CHEMISTRY (2-4)** Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions.

514. CHARACTERIZATION OF MATERIALS (3) Classical and new (microprobe, scanning microscope, magnetic resonance, and Mossbauer) techniques for the characterization of composition, structure, defects, and surfaces.

524. (G.M. 524) VIBRATIONAL SPECTRA OF MATERIALS AND MINERALS (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization, and glass research. Prerequisites: Phys. 412, 471.

531. (G.M. 531) TRANSMISSION ELECTRON MICROSCOPY (2) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences. Prerequisite: Mat.Sc. 411B (Min. 411B).

532. (G.M. 532) STRUCTURE ANALYSIS (2) Crystal structure determination methods; space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Mat.Sc. 408 (Geosc. 408).

533. (G.M. 533) SINGLE CRYSTAL METHODS (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Mat.Sc. 408 (Geosc. 408).

534. (G.M. 534) DIFFRACTION BY CRYSTALS (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescence, polarization. Prerequisite: Mat.Sc. 408 (Geosc. 408).

535. (G.M. 535) GEOMETRICAL CRYSTALLOGRAPHY (3) Derivation of lattices, types, point groups, and space groups, with applications.

538. (G.M. 538) ELECTRON BEAM ANALYSIS OF SOLIDS VIA X-RAY AND ELECTRON EMISSION (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids.

540. CRYSTAL ANISOTROPY (3) Symmetry aspects of crystals and physical properties. Matrix and tensor methods. Prerequisite: Phys. 412.

542. MAGNETIC METHODS IN MATERIALS SCIENCE (3) Static magnetic (susceptibility type) and spectroscopic methods (nuclear and electron magnetic resonance, Mossbauer spectroscopy) for materials characterization and structural analysis. Prerequisite: Phys. 413.

552. THEORY AND PRACTICE OF CRYSTAL GROWTH (3) Theoretical approaches to crystal growth and of the various techniques used in growing crystals.

554. ELECTRONIC SPECTRA OF MATERIALS (3) Crystallographic and thermodynamic applications of crystal field theory. Electronic spectra of crystals and glasses. Luminescent spectra and phosphor characterization. Prerequisite: Phys. 471.

570. CATALYTIC MATERIALS (3) Preparation and characterization of solid catalytic materials. Relationships between their surface, defect, and electronic properties and catalytic activity. Prerequisite: Chem. 452.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

MINERAL ENGINEERING (MIN E)

414. PLANNING AND CONTROL FOR THE MINERAL INDUSTRIES (3)

415. MANAGEMENT IN THE MINERAL INDUSTRIES FOR ENVIRONMENTAL, LEGAL, AND HEALTH AND SAFETY PROBLEMS (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

PATHOLOGY (PATH)

501. PRINCIPLES OF PATHOLOGY (4) The fundamentals of reaction to injury at cellular and tissue levels emphasizing the pathogenesis of functional, structural, and biochemical abnormalities.

520. **BIOLOGY OF NEOPLASIA (3)** Detailed examination of the initiation and pathogenesis of animal neoplasms with emphasis on the relationship to human neoplasia. Prerequisite: admission to College of Medicine.

522. **CANCER IMMUNOLOGY AND IMMUNOTHERAPY (2)** Detailed study of recent advances in host response to malignancy in man and experimental animals. Prerequisite: Path. 501 or Micrb. 554.

597. **SPECIAL TOPICS (1-6)**

PEDIATRICS (PED)

525. **CLINICAL GENETICS (5-10)** Mendelian and molecular principles of human genetics; genetic bases of human disease, quantitative human genetics, prenatal diagnosis, genetic counseling.

526. **HUMAN CYTOGENETICS (2)** Human chromosome identification; structure, replication, and evolution of human and other eukaryotic chromosomes in cytogenetic and molecular terms.

PLANT SCIENCE (PLTSC)

400. **PRINCIPLES OF PLANT SCIENCE RESEARCH (2)**

496. **INDEPENDENT STUDIES (1-12)**

497. **SPECIAL TOPICS (1-6)**

POLYMER SCIENCE (PLMSC)

400. **POLYMERIC MATERIALS (3)**

406. **INTRODUCTION TO THE MATERIALS SCIENCE OF POLYMERS (3)**

407. **TECHNOLOGY AND APPLICATIONS OF POLYMERIC MATERIALS (3)**

409. **INTRODUCTION TO PROPERTIES OF POLYMERIC MATERIALS (3)**

410. **POLYMER-BASED COMPOSITE MATERIALS (3)**

411. **SMALL ANGLE X-RAY SCATTERING (2)**

412. **POLYMERIC MATERIALS LABORATORY — SYNTHESIS (2)**

413. **POLYMERIC MATERIALS LABORATORY — CHARACTERIZATION (2)**

490. **POLYMER SCIENCE SEMINAR (1)**

496. **INDEPENDENT STUDIES (1-12)**

497. **SPECIAL TOPICS (1-6)**

520. **POLYMER CRYSTALS (2)** Morphology, characterization, and properties of polymer crystals. Review of electron microscopy, thermal analysis, X-ray density, and chemical degradation studies. Prerequisite: Plm.Sc. 407 or 409.

521. **POLYMER VIBRATIONAL SPECTROSCOPY I (3)** The description, theory, and application of infrared and Raman spectroscopies as applied to polymeric materials. Prerequisites: Math. 240; Chem. 33 or Plm.Sc. 406.

522. **POLYMER VIBRATIONAL SPECTROSCOPY II (3)** The theory and application of normal coordinate analysis as applied to polymeric materials. Prerequisites: Math. 260; Cmp.Sc. 101 or 201.

POPULATION ISSUES

Qualified students may select population issues studies as an option of specialization when majoring in economics, geography, sociology, anthropology, rural sociology, or agricultural economics. Additional information is given under the description of those majors in the preceding section.

PORTUGUESE (PORT)

456. **BRAZILIAN LITERATURE IN ENGLISH TRANSLATION (3)**

588. **SEMINAR IN PORTUGUESE AND BRAZILIAN LITERATURE (3-12)** Common and individual research in special problems.

SAFETY EDUCATION (SAFED)

- 449. SAFETY EDUCATION (3)
- 450. VISUAL AND OTHER AIDS IN SAFETY EDUCATION (3)
- 451. TEACHING TRAFFIC SAFETY AND AUTOMOBILE OPERATION (3)
- 452. ORGANIZATION AND SUPERVISION IN SAFETY EDUCATION (3)
- 453. MOTOR VEHICLE LAW (3)
- 454. LEISURE TIME VEHICLE SAFETY EDUCATION (3)
- 455. TEACHING SAFE MOTORCYCLE OPERATION (3)
- 496, 496v. INDEPENDENT STUDIES (1-12)
- 497, 497v. SPECIAL TOPICS (1-6)

SCIENCE (SC)

- 400. CONSEQUENCES OF SCIENCE (1)

SCIENCE, TECHNOLOGY, AND SOCIETY (S T S)

- 410. (Engr. 410) TECHNOLOGY: ITS CHARACTER, ROLE, AND FUNCTION (3)
- 420. (E.M.Sc. 420) ENERGY AND MODERN SOCIETY (3)
- 421. (E.M.Sc. 421) MATERIALS AND MODERN SOCIETY (3)
- 430. FOOD AND MAN: TECHNOLOGY AND FEEDING THE WORLD POPULATION (3)
- 432. (Phil. 432) MEDICAL ETHICS (3)
- 435. (Phil. 435) THE INTERRELATION OF SCIENCE, PHILOSOPHY, AND RELIGION (3)
- 460. SCIENCE AND PUBLIC POLICY (3)
- 470. TECHNOLOGY ASSESSMENT AND INDICATORS OF THE QUALITY OF LIFE (3)
- 471. RADIATION, REACTORS, AND SOCIETY (3)
- 480. (L.A. 480) TECHNOLOGICAL CHANGE AND HUMAN VALUES (3)
- 496. INDEPENDENT STUDIES (1-12)

NOTE: This program is designed to examine critically the impact of scientific investigation and technological development on society and the influence of human needs on scientific investigation and technological development.

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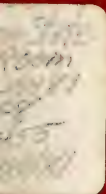
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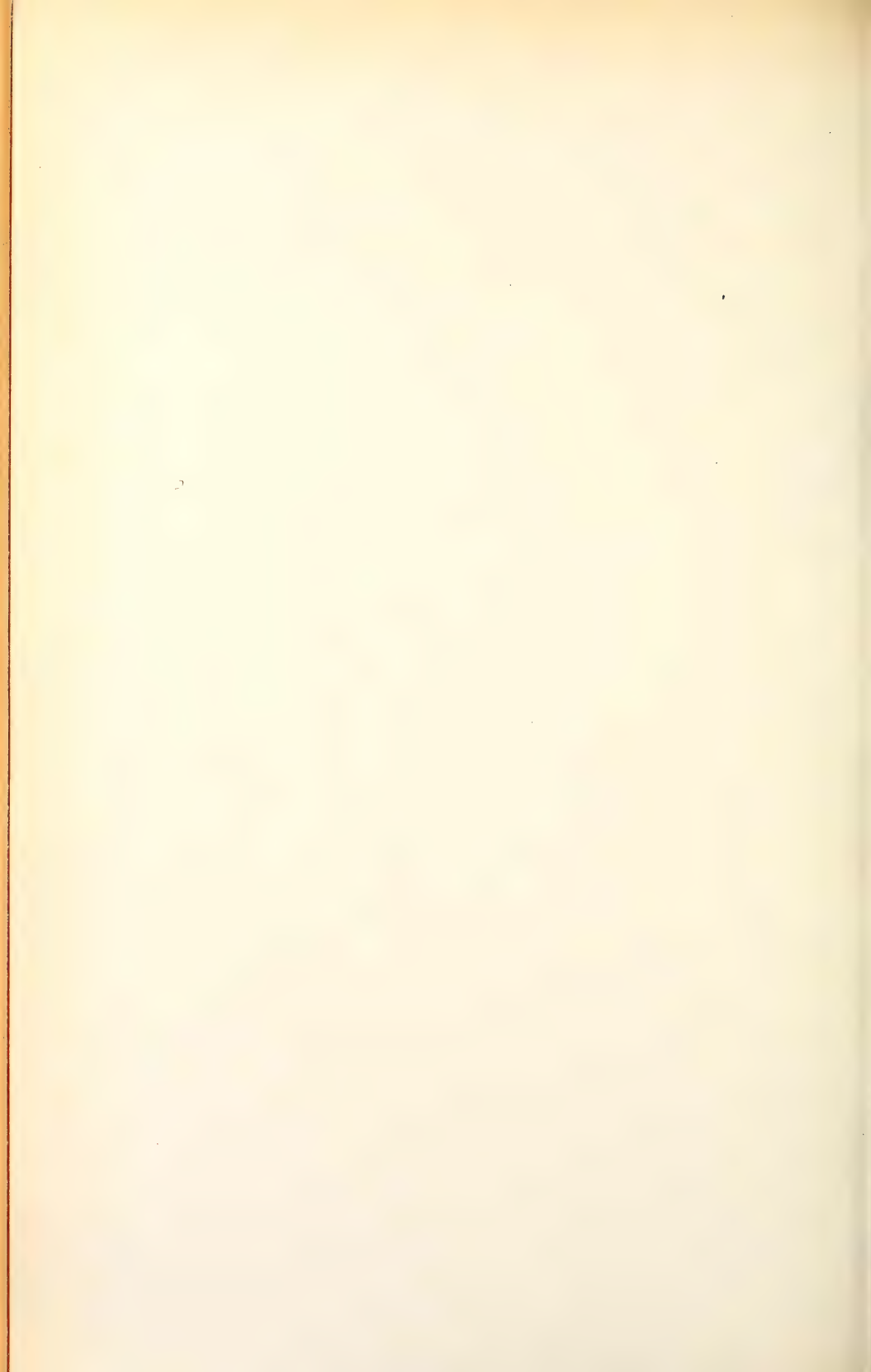
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Graduate Degree Programs





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SEPTEMBER 1980**

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REGULATIONS SUBJECT TO CHANGE

The educational process necessitates change. This bulletin must be considered as informational and not binding on the University.

Each step of the educational process, from admission through graduation, requires continuing review and appropriate approval by University officials. The University, therefore, reserves the right to change the requirements and regulations contained in this bulletin and to determine whether a student has satisfactorily met its requirements for admission or graduation, and to reject any applicant for admission for any reason the University determines to be material to the applicant's qualification to pursue higher education. Nothing in this bulletin should be considered a guarantee that completion of a program and graduation from the University will result in employment.

The Pennsylvania State University, in compliance with federal and state laws and regulations governing affirmative action and nondiscrimination, does not discriminate in the recruitment, admission, and employment of students, faculty, and staff in the operation of any of its educational programs and activities as defined by law. Accordingly, nothing in this publication should be viewed as directly or indirectly expressing any limitation, specification, or discrimination as to race, religion, color, or national origin; or to handicap, age, sex, or status as a disabled or Vietnam-era veteran, except as provided by law. Inquiries concerning this policy may be directed to the vice president for student affairs.

GRADUATE CALENDAR*

FALL TERM 1980

AUGUST 1980

- 4 Monday — Last date for a prospective graduate student to submit completed application materials for admission to the fall term 1980
- 4 Monday — Last date for a graduate student to apply for permission to resume study in the fall term 1980

SEPTEMBER

- 3-5 Wednesday noon to Friday — Fall term registration
- 8 Monday — Fall term classes begin 8:00 A.M.
- 19 Friday — Deadline for applying for graduate school tuition grant-in-aid for winter term 1981
- 22 Monday — Last date for a November graduate to pay thesis fee at Bursar's Office and to activate diploma card in Records Office

OCTOBER

- 4 Saturday — Last date for a November graduate to deliver doctoral thesis to committee
- 11 Saturday — Last date for final oral doctoral examinations for November graduates
- 11 Saturday — Last date for a November graduate to deliver master's thesis or paper to adviser
- 13 Monday — Last date for a November graduate to submit camera-ready thesis manuscript to Thesis Office
- 27 Monday — Last date for a November graduate to deliver thesis to Graduate School
- 27 Monday — Last date for departments to certify to Graduate School completion of required papers for November graduates
- 27 Monday — Date for a November graduate to order cap, gown, and hood locally

NOVEMBER

- 14 Friday — Last date for submitting a petition to the Records Office to graduate *in absentia* in November
- 15 Saturday — Fall term classes end 12:25 P.M.
- 17-21 Monday to Thursday — Final examinations
- 27 Thursday — Thanksgiving Day holiday
- 29 Saturday — Commencement

*This calendar is subject to change without notice. In preparing the calendar for an academic year, the University makes every effort to avoid conflicts with religious holidays. However, such conflicts are sometimes unavoidable. When they occur, efforts are made to make special arrangements for the students affected.

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Graduate Programs, 211 Kern Graduate Building. Times and places of tests will be announced when the application is filed.

WINTER TERM 1981

NOVEMBER 1980

- 3 Monday — Last date for a prospective graduate student to submit completed application materials for admission to the winter term 1981
- 3 Monday — Last date for a graduate student to apply for permission to resume study in the winter term 1981

DECEMBER

- 2, 3 Tuesday, Wednesday — Winter term registration
- 4 Thursday — Winter term classes begin 8:00 A.M.
- 16 Tuesday — Last date for a March graduate to pay thesis fee at Bursar's Office *and* to activate diploma card in Records Office
- 20 Saturday — Winter term recess begins 12:25 P.M.

JANUARY 1981

- 4 Sunday — Winter term recess ends
- 5 Monday — Winter term classes resume 8:00 A.M.
- 6 Tuesday — Deadline for applying for Graduate School tuition grant-in-aid for spring term 1981
- 10 Saturday — Last date for a March graduate to deliver doctoral thesis to committee
- 17 Saturday — Last date for final oral doctoral examinations for March graduates
- 17 Saturday — Last date for a March graduate to deliver master's thesis or paper to adviser
- 19 Monday — Last date for a March graduate to submit camera-ready thesis manuscript to Thesis Office

FEBRUARY

- 2 Monday — Last date for a March graduate to deliver thesis to Graduate School
- 2 Monday — Last date for departments to certify to Graduate School completion of required papers for March graduates
- 2 Monday — Date for a March graduate to order cap, gown, and hood locally
- 2 Monday — Deadline for applying for fellowships through any of the Graduate School programs
- 20 Friday — Last date for submitting a petition to the Records Office to graduate *in absentia* in March
- 26 Thursday — Winter term classes end 12:25 P.M.
- 27, 28 Friday, Saturday — Final examinations

MARCH

- 8 Saturday — Commencement

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Graduate Programs, 211 Kern Graduate Building. Times and places of tests will be announced when the application is filed.

SPRING TERM 1981

FEBRUARY 1981

- 10 Tuesday — Last date for a prospective graduate student to submit completed application materials for admission to the spring term 1981
- 10 Tuesday — Last date for a graduate student to apply for permission to resume study in the spring term 1981

MARCH

- 10, 11 Tuesday, Wednesday — Spring term registration
- 12 Thursday — Spring term classes begin 8:00 A.M.
- 24 Tuesday — Last date for a May graduate to pay thesis fee at Bursar's Office *and* to activate diploma card in Records Office

APRIL

- 3 Friday — Deadline for applying for Graduate School tuition grant-in-aid for summer term 1981 and fall term 1981
- 4 Saturday — Last date for a May graduate to deliver doctoral thesis to committee
- 11 Saturday — Last date for final oral doctoral examinations for May graduates
- 11 Saturday — Last date for a May graduate to deliver master's thesis or paper to adviser
- 13 Monday — Last date for a May graduate to submit camera-ready thesis manuscript to Thesis Office
- 27 Monday — Last date for a May graduate to deliver thesis to Graduate School
- 27 Monday — Date for departments to certify to Graduate School completion of required papers for May graduates
- 27 Monday — Date for a May graduate to order cap, gown, and hood locally

MAY

- 15 Friday — Last date for submitting a petition to the Records Office to graduate *in absentia* in May
- 20 Wednesday — Spring term classes end 9:55 P.M.
- 21-23, 25 Thursday to Saturday, Monday — Final examinations
- 30 Saturday — Commencement

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Graduate Programs, 211 Kern Graduate Building. Times and places of tests will be announced when the application is filed.

SUMMER TERM 1981

MAY 1981

- 8 Friday — Last date for a prospective graduate student to submit completed application materials for admission to the summer term 1981
- 8 Friday — Last date for a graduate student to apply for permission to resume study in the summer term 1981

JUNE

- 9 Tuesday — Summer term registration
- 10 Wednesday — Summer term classes begin 8:00 A.M.
- 22 Monday — Last date for an August graduate to pay thesis fee at Bursar's Office *and* to activate diploma card in Records Office

JULY

- 4 Saturday — Independence Day holiday
- 6 Monday — Last date for an August graduate to deliver doctoral thesis to committee
- 11 Saturday — Last date for an August graduate to deliver master's thesis or paper to adviser
- 13 Monday — Last date for final oral doctoral examinations for August graduates
- 13 Monday — Last date for an August graduate to submit camera-ready thesis manuscript to Thesis Office
- 27 Monday — Date for an August graduate to deliver thesis to Graduate School
- 27 Monday — Last date for departments to certify to Graduate School completion of required papers for August graduates
- 27 Monday — Date for an August graduate to order cap, gown, and hood locally

AUGUST

- 14 Friday — Last date for submitting a petition to the Records Office to graduate *in absentia* in August
- 19 Wednesday — Summer term classes end 9:55 P.M.
- 20-22 Thursday to Saturday — Final examinations
- 29 Saturday — Commencement

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Graduate Programs, 211 Kern Graduate Building. Times and places of tests will be announced when the application is filed.

FALL TERM 1981

AUGUST 1981

- 3 Monday — Last date for a prospective graduate student to submit completed application materials for admission to the fall term 1981
- 3 Monday — Last date for a graduate student to apply for permission to resume study in the fall term 1981

SEPTEMBER

- 2-4 Wednesday noon to Friday — Fall term registration
- 7 Monday — Labor Day holiday
- 8 Tuesday — Fall term classes begin 8:00 A.M.
- 18 Friday — Last date for applying for Graduate School tuition grant-in-aid for winter term 1982
- 21 Monday — Last date for a November graduate to pay thesis fee at Bursar's Office *and* to activate diploma card in Records Office

OCTOBER

- 3 Saturday — Last date for a November graduate to deliver doctoral thesis to committee
- 10 Saturday — Last date for final oral doctoral examinations for November graduates
- 10 Saturday — Last date for a November graduate to deliver master's thesis or paper to adviser
- 12 Monday — Last date for a November graduate to submit camera-ready thesis manuscript to Thesis Office
- 26 Monday — Last date for a November graduate to deliver thesis to Graduate School
- 26 Monday — Last date for departments to certify to Graduate School completion of required papers for November graduates
- 26 Monday — Date for a November graduate to order cap, gown, and hood locally

NOVEMBER

- 13 Friday — Last date for submitting a petition to the Records Office to graduate *in absentia* in November
- 16 Monday — Fall term classes end 9:55 P.M.
- 17-20 Tuesday to Friday — Final examinations
- 26 Thursday — Thanksgiving Day holiday
- 28 Saturday — Commencement

NOTE: Students who plan to take examinations in French and Spanish should apply through the Office of Graduate Programs, 211 Kern Graduate Building. Times and places of tests will be announced when the application is filed.

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 ROY W. ALLISON, Sr., D.Ed. (Penn State) *Associate Professor of Education*
 WILLIAM H. ALLISON, M.F.A. (Yale) *Professor of Theatre Arts*
 JOHN O. ALMQUIST, Ph.D. (Penn State) *Professor of Dairy Physiology*
 THEODORE R. ALTER, Ph.D. (Michigan State) *Assistant Professor of Agricultural Economics*
 CHARLES D. AMERINGER, Ph.D. (Fletcher Sch. Law & Dipl.) *Prof. of Latin Am. History*
 RICHARD I. AMMON, Jr., D.Ed. (Penn State) *Assistant Professor of Education*
 ALBERT A. ANDERSON, Ph.D. (Ohio State) *Associate Professor of Art Education*
 ARTHUR ANDERSON, Jr., M.F.A. (Princeton) *Associate Professor of Architecture*
 DAVID A. ANDERSON, Ph.D. (Purdue) *Associate Professor of Civil Engineering*
 DON L. ANDERSON, Ph.D. (Illinois) *Assistant Professor of Industrial Engineering*
 ELIZABETH P. ANDERSON, Ph.D. (Minnesota) *Assistant Professor of Human Development*
 JAMES B. ANDERSON, Ph.D. (Princeton) *Professor of Chemistry*
 JOEL H. ANDERSON, Ph.D. (Indiana) *Assistant Professor of Mathematics*
 GEORGE E. ANDREWS, Ph.D. (Pennsylvania) *Professor of Mathematics*
 RICHARD A. ANTHES, Ph.D. (Wisconsin) *Professor of Meteorology*
 ADAM ANTHONY, Ph.D. (Chicago) *Professor of Zoology*
 CHARLES E. ANTLE, Ph.D. (Oklahoma State) *Professor of Statistics*
 FRANK F. APLAN, Sc.D. (M.I.T.) *Professor of Mineral Processing*
 FRANK S. ARCHIBALD, Ph.D. (Cambridge) *Res. Assoc. at Applied Research Laboratory*
 ROBERT ARIEW, Ph.D. (Illinois) *Assistant Professor of French*
 STEVE ARMENTROUT, Ph.D. (Texas) *Professor of Mathematics*
 DEAN E. ARNOLD, Ph.D. (Cornell) *Assistant Professor of Biology*
 JUDD B. ARNOLD, Ph.D. (Connecticut) *Associate Professor of English*
 MARY F. ARNOLD, D.P.H. (Calif.) *Professor of Health Planning*
 STEVEN F. ARNOLD, Ph.D. (Stanford) *Assistant Professor of Statistics*
 GERT ARON, Ph.D. (California), P.E. *Associate Professor of Civil Engineering*
 NATHAN N. ARONSON, Jr., Ph.D. (Duke) *Associate Professor of Biochemistry*
 RALPH G. ASCAH, Ph.D. (New York) *Associate Professor of Chemistry*
 S. ASHOK, Ph.D. (Rensselaer Polytech.) *Assistant Professor of Engineering Science*
 EUNICE N. ASKOV, Ph.D. (Wisconsin) *Professor of Education*
 VERNON V. ASPATURIAN, Ph.D. (U.C.L.A.) *Evan Pugh Professor of Political Science*
 DEBORAH S. AUSTIN, Ph.D. (Bryn Mawr) *Professor of English*

*Printer deadlines prohibit changes in the Graduate Faculty listings under graduate major programs after March 31, 1980.

- LEONARD G. AUSTIN, Ph.D. (Penn State) *Professor of Fuels and Mineral Engineering*
 ROY L. AUSTIN, Ph.D. (Washington) *Assistant Professor of Sociology*
 PAUL AXT, Ph.D. (Wisconsin) *Professor of Mathematics*
 JOHN E. AYERS, Ph.D. (Penn State) *Professor of Plant Pathology*
 CHRISTINE W. AYOUB, Ph.D. (Yale) *Professor of Mathematics*
 RAYMOND G. D. AYOUB, Ph.D. (Illinois) *Professor of Mathematics*
 WILLEM ADRIANUS BAAN, Ph.D. (M.I.T.) *Assistant Professor of Astronomy*
 CLIFTON A. BAILE, Ph.D. (Missouri) *Adjunct Associate Professor of Animal Nutrition*
 IRWIN L. BAIRD, Ph.D. (Harvard) *Professor of Anatomy*
 ROBERT W. BAISLEY, M.A. (Columbia) *Professor of Music*
 DALE E. BAKER, Ph.D. (Missouri) *Professor of Soil Chemistry*
 PAUL T. BAKER, Ph.D. (Harvard) *Professor of Anthropology*
 STANLEY B. BAKER, Ph.D. (S.U.N.Y.) *Associate Professor of Education*
 WALTER L. BAKER, M.S. (Penn State), P.E. *Professor of Engineering Research*
 JOHN BALABAN, A.M. (Harvard) *Associate Professor of English*
 PHILIP H. BALDI, Ph.D. (Rochester) *Associate Professor of Linguistics*
 ROBERT C. BALDWIN, Ph.D. (Penn State) *Asst. Professor of Wood Science and Technology*
 MARGRET M. BALTES, Ph.D. (West Virginia) *Asst. Prof. of Human Development and Nursing*
 PAUL B. BALTES, Ph.D. (Saarland, Germany) *Professor of Human Development*
 HUBERT L. BARNES, Ph.D. (Columbia) *Professor of Geochemistry*
 STEVEN M. BARNES, Ph.D. (Michigan State) *Assistant Professor of Education*
 ROBERT M. BARNOFF, Ph.D. (Carnegie Tech.), P.E. *Professor of Civil Engineering*
 GERHARD R. BARSCH, Dr.rer.nat. (Göttingen) *Professor of Physics*
 GERHARD BARTH, Ph.D. (U. Kaiserslautern) *Assistant Professor of Computer Science*
 GERALD L. BARTLETT, Ph.D. (Pennsylvania) *Associate Professor of Pathology and Microbiology*
 HOWARD D. BARTLETT, M.S. (Maine), P.E. *Professor of Agricultural Engineering*
 MICHAEL L. BARTON, Ph.D. (Pennsylvania) *Associate Professor of Social Science*
 PAUL BARTON, Ph.D. (Penn State), P.E. *Assistant Professor of Chemical Engineering*
 RICHARD L. BARTON, Ph.D. (Oregon) *Associate Professor of Speech Communication*
 JAMES B. BARTOO, Ph.D. (Iowa) *Professor of Mathematical Statistics*
 EUGENIO BATTISTI, Perfezionamento (Rome) *Evan Pugh Professor of Art History*
 BILLY R. BAUMGARDT, Ph.D. (Rutgers) *Professor of Animal Nutrition*
 JOHN E. BAYLOR, Ph.D. (Penn State) *Professor of Agronomy Extension*
 ROBERT C. BEALER, Ph.D. (Michigan State) *Professor of Rural Sociology*
 ROBERT M. BEAR, Ph.D. (Iowa) *Associate Professor of Finance*
 DAVID J. BEATTIE, Ph.D. (Michigan State) *Assistant Professor of Ornamental Horticulture*
 ALICE F. BEATTY, Ph.D. (Louisiana State) *Professor of Biology and Entomology*
 PHILIP M. BECKER, Ph.D. (Minnesota) *Assistant Professor of Fuel Science*
 ROBERT BEELMAN, Ph.D. (Ohio State) *Associate Professor of Food Science*
 MICHAEL H. BEGNAL, Ph.D. (Washington) *Professor of English and Comparative Literature*
 JAMES G. BEIERLEIN, Ph.D. (Purdue) *Asst. Prof. of Agricultural Economics*
 LELAND L. BEIK, Ph.D. (Columbia) *Professor of Marketing*
 KENNETH R. BEITTEL, D.Ed. (Penn State) *Professor of Art Education*
 PAUL E. BELL, D.Ed. (Oregon) *Associate Professor of Education*
 EDWARD D. BELLIS, Ph.D. (Minnesota) *Professor of Biology*
 JAY BELSKY, Ph.D. (Cornell) *Assistant Professor of Human Development*
 STEPHEN J. BENKOVIC, Ph.D. (Cornell) *Evan Pugh Professor of Chemistry*
 PETER D. BENNETT, Ph.D. (Texas) *Professor of Marketing*
 JAMES D. BENSHOOF, M.A. (Penn State) *Assistant Professor of Music*
 BRUCE L. BENSON, Ph.D. (Texas A & M) *Assistant Professor of Economics*
 THOMAS W. BENSON, Ph.D. (Cornell) *Professor of Speech Communication*
 ALLEN W. BENTON, Ph.D. (Cornell) *Professor of Entomology*
 CLYDE C. BERG, Ph.D. (Washington State) *Adjunct Assistant Professor of Agronomy*
 ERNEST L. BERGMAN, Ph.D. (Michigan State) *Professor of Plant Nutrition*
 ASA J. BERLIN, Mh.D. (Northwestern) *Professor of Speech Pathology*
 CHESTON M. BERLIN, M.D. (Harvard) *Professor of Pediatrics and Pharmacology*
 R. THOMAS BERNER, M.A. (Penn State) *Assistant Professor of Journalism*
 ROBERT A. BERNHEIM, Ph.D. (Illinois) *Professor of Chemistry*

- ROBERT W. BERNLOHR, Ph.D. (Ohio State) *Professor of Biochemistry*
 JOHN H. BEST, Ph.D. (North Carolina) *Professor of Education*
 KARL H. BEYER, Jr., Ph.D. (Wisconsin) *Adjunct Professor of Pharmacology*
 VEERASINGHAM P. BHAVANANDAN, Ph.D. (Edinburgh) *Assoc. Professor of Biological Chemistry*
 Z. T. BIENIAWSKI, D.Sc. (Pretoria) *Professor of Mineral Engineering*
 GORDON R. BIENVENUE, Ph.D. (Penn State) *Research Associate in Audiology*
 JAMES V. BIGGERS, Ph.D. (Penn State) *Sr. Res. Associate at Materials Research Laboratory*
 WILLIAM E. BILES, Ph.D. (Virginia Polytechnic) *Professor of Industrial Engineering*
 SIGMUND S. BIRKENMAYER, Ph.D. (Wisconsin) *Professor of Slavic Languages*
 BARNARD H. BISSINGER, Ph.D. (Cornell) *Professor of Mathematics*
 STEWART W. BITHER, D.B.A. (Washington) *Professor of Marketing*
 WILLIAM R. BITLER, Ph.D. (Carnegie Tech.) *Professor of Metallurgy*
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 ALFRED K. BLACKADAR, Ph.D. (New York) *Professor of Meteorology*
 ROBERT O. BLANCHARD, Ph.D. (Syracuse) *Professor of Journalism*
 PAUL R. BLANKENHORN, Ph.D. (Penn State) *Assistant Professor of Wood Technology*
 JAMES G. BLENCOE, Ph.D. (Stanford) *Assistant Professor of Geochemistry*
 ERNST BLEULER, D.Sc.Nat. (Zürich), habil. *Professor of Physics*
 MERY P. BLIESMER, Ph.D. (Iowa State) *Professor of Education*
 JAMES R. BLOOM, Ph.D. (Wisconsin) *Professor of Plant Pathology*
 ALLEN C. BLUEDORN, Ph.D. (Iowa) *Assistant Professor of Organizational Behavior*
 MELVIN BLUMBERG, Ph.D. (Penn State) *Assistant Professor of Management*
 WILLIAM M. BODE, Ph.D. (Ohio State) *Assistant Professor of Entomology*
 JEAN-HUGUES A. BOISSET, Ph.D. (Florida) *Assistant Professor of French*
 JEAN-MARC BOLLAG, Ph.D. (Basel) *Professor of Soil Microbiology*
 RICHARD C. BOLLINGER, Ph.D. (Pittsburgh) *Associate Professor of Mathematics*
 ROBERT S. BOND, Ph.D. (S.U.N.Y) *Professor of Forest Resources*
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 ELMER W. BORKLUND, Ph.D. (Chicago) *Professor of English*
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 EUGENE N. BORZA, Ph.D. (Chicago) *Associate Professor of History*
 MARILYN T. BOSWELL, Ph.D. (California) *Assistant Professor of Mathematical Statistics*
 TODD W. BOWERSOX, Ph.D. (Penn State) *Assistant Professor of Silviculture*
 J. DAVID BOYLE, Ph.D. (Kansas) *Professor of Music Education*
 JOHN S. BOYLE, Ph.D. (Wisconsin) *Professor of Plant Pathology*
 JOSEPH F. BRADLEY, Ph.D. (Pittsburgh) *Professor of Finance*
 WILLIAM R. BRADLEY, Ph.D. (Minnesota) *Associate Professor of Art Education*
 RICHARD C. BRADT, Ph.D. (Rensselaer Polytech.) *Professor of Ceramic Science*
 JEANNETTE DANIELLE BRAGGER, Ph.D. (California) *Assistant Professor of French*
 SEYMOUR T. BRANTNER, Ed.D. (Pittsburgh) *Associate Professor of Industrial Education*
 GÉRARD J. BRAULT, Ph.D. (Pennsylvania) *Professor of French*
 ROBERT W. BRENNAN, M.D. (Cornell) *Professor of Medicine*
 ROBERT J. BRESLER, Ph.D. (Princeton) *Assoc. Prof. of Social Science and Political Science*
 DAVID MARIUS BRESSOUD, Ph.D. (Temple) *Assistant Professor of Mathematics*
 JEAN O. BRITTON, Ph.D. (Chicago) *Professor of Education and Psychology*
 JOSEPH H. BRITTON, Ph.D. (Chicago) *Professor of Human Development*
 DAVID J. BROWN, Ph.D. (Ohio State) *Affiliate Assistant Professor of Psychology*
 EMORY J. BROWN, Ph.D. (Michigan State) *Professor of Rural Sociology*
 FREDERICK M. BROWN, Ph.D. (Virginia) *Assoc. Professor of Psychology*
 IRA V. BROWN, Ph.D. (Harvard) *Professor of American History*
 J. CUDD BROWN, Ph.D. (Oregon) *Professor of Political Science*
 JOHN L. BROWN, Jr., Ph.D. (Brown) *Professor of Electrical Engineering*
 RAYMOND H. BROWN, B.S. (Johns Hopkins) *Professor of Music*
 ROBERT J. BROWN, Ph.D. (New York) *Associate Professor of Finance*
 TERENCE A. BROWN, D.B.A. (Maryland) *Associate Professor of Business Logistics*
 WOODROW D. BROWNAWELL, Ph.D. (Cornell) *Professor of Mathematics*
 BARTON W. BROWNING, Ph.D. (California) *Associate Professor of German*

- ROBERT S. BRUBAKER, Ph.D. (Illinois) *Professor of Speech Communication*
 JOHN D. C. BUCK, Ph.D. (California) *Assistant Professor of English*
 ROY C. BUCK, Ph.D. (Minnesota) *Professor of Sociology and Social Science*
 RONALD E. BUCKALEW, Ph.D. (Illinois) *Associate Professor of English*
 JORUNN BUCKLEY, Ph.D. (Chicago) *Assistant Professor of Religious Studies*
 EDWARD C. BUDD, Ph.D. (California) *Professor of Economics*
 JOE P. BUHLER, Ph.D. (Harvard) *Assistant Professor of Mathematics*
 BRUCE BULLINGTON, Ph.D. (California) *Associate Professor of the Administration of Justice*
 LESLIE P. BULLOCK, D.V.M. (California) *Associate Professor of Comparative Medicine*
 LESTER A. BURDETTE, Ph.D. (Penn State) *Professor of Animal Science Extension*
 ROBERT L. BURGESS, Ph.D. (Washington, St. Louis) *Professor of Human Development*
 C. WAYNE BURNHAM, Ph.D. (California Tech.) *Professor of Geochemistry*
 LANDON C. BURNS, Ph.D. (Yale) *Professor of English*
 JOHN E. BURRIS, Ph.D. (California) *Assistant Professor of Biology*
 ELI D. BUSKIRK, JR., Ph.D. (Michigan) *Assistant Professor of Regional Planning*
 ELSWORTH R. BUSKIRK, Ph.D. (Minnesota) *Professor of Applied Physiology*
 EDWARD G. BUSS, Ph.D. (Purdue) *Professor of Poultry Science*
 ROBERT L. BUTLER, Ph.D. (Minnesota) *Professor of Biology*
 DAVID E. BUTT, D.Ed. (Penn State) *Associate Professor of Speech Communication*
 ROBERT L. BUTTERWORTH, Ph.D. (California) *Associate Professor of Political Science*
 ROBERT A. BYERS, Ph.D. (Purdue) *Adjunct Associate Professor of Entomology*
 PHILIP D. CADY, Ph.D. (Penn State), P.E. *Professor of Civil Engineering*
 JOHN J. CAHIR, Ph.D. (Penn State) *Professor of Meteorology*
 WILLIAM E. CALDWELL, Ph.D. (New York) *Associate Professor of Education*
 THOMAS M. CALLAGHY, Ph.D. (California) *Assistant Professor of Political Science*
 FRANCIS P. CALLAHAN, Ph.D. (Pennsylvania) *Assoc. Professor of Industrial Engineering*
 E. ALAN CAMERON, Ph.D. (California) *Associate Professor of Entomology*
 C. SEYMOUR CARD, Ph.D. (Colorado State) *Professor of Veterinary Science*
 TOBY N. CARLSON, Ph.D. (Imperial, London) *Associate Professor of Meteorology*
 LYNN A. CARPENTER, Ph.D. (Illinois) *Associate Professor of Electrical Engineering*
 JOSEPH L. CARROLL, D.B.A. (Indiana) *Professor of Business Administration*
 ROBERT W. CARRUBBA, Ph.D. (Princeton) *Professor of Classics*
 CAROL A. CARTWRIGHT, Ph.D. (Pittsburgh) *Professor of Education*
 G. PHILLIP CARTWRIGHT, Ph.D. (Pittsburgh) *Professor of Special Education*
 ERSKINE H. CASH, Ph.D. (Michigan State) *Associate Professor of Animal Science*
 LESTER E. CASIDA, JR., Ph.D. (Wisconsin) *Professor of Microbiology*
 LAWRENCE CATHLES III, Ph.D. (Princeton) *Associate Professor of Geosciences*
 PETER R. CAVANAGH, Ph.D. (Royal Free Medical) *Assoc. Professor of Biomechanics*
 JOSEPH L. CAVINATO, Ph.D. (Penn State) *Assistant Professor of Business Logistics*
 RONALD A. CHADDERTON, Ph.D. (Carnegie-Mellon) *Assistant Professor of Civil Engineering*
 NAPOLEON A. CHAGNON, Ph.D. (Michigan) *Professor of Anthropology*
 MOSES H.-W. CHAN, Ph.D. (Cornell) *Assistant Professor of Physics*
 PARRIS H. CHANG, Ph.D. (Columbia) *Professor of Political Science*
 SALLY CHANT, Ph.D. (Michigan State) *Assistant Professor of Reading*
 HUGH H. CHAPMAN, JR., Ph.D. (Harvard) *Professor of Romance Languages*
 DAVID R. CHASE, Ph.D. (Texas A&M) *Assoc. Prof. of Recreation and Parks*
 KALYAN CHATTERJEE, D.B.A. (Harvard) *Assistant Professor of Management Science*
 GOONG CHEN, Ph.D. (Wisconsin) *Assistant Professor of Mathematics*
 CHARLES C. CHERRY, Ph.D. (Drew) *Professor of Religious Studies*
 RUPERT F. CHISHOLM, Ph.D. (Case Western Reserve) *Assistant Professor of Management*
 NANCY R. CHISWICK, Ph.D. (Illinois) *Affiliate Assistant Professor of Psychology*
 YAR G. CHOMICKY, M.S. (Penn State) *Professor of Art Education*
 PAROMITA CHOWLA, Ph.D. (Colorado) *Associate Professor of Mathematics*
 MONTY L. CHRISTIANSEN, M.L.A. (Iowa State) *Assoc. Prof. of Landscape Architecture and Recreation and Parks*
 ROBERT W. CHRISTINA, Ph.D. (Maryland) *Professor of Physical Education*
 ETON FREDERICK CHURCHILL, M.F.A. (Tulane) *Assoc. Prof. of Humanities and Multimedia Journalism*

STEPHEN J. CIMBALA, Ph.D. (Wisconsin) *Associate Professor of Political Science*
 EDWARD J. CIOLKOSZ, Ph.D. (Wisconsin) *Prof. of Soil Genesis and Morphology*
 JOHN H. E. CLARK, Ph.D. (Florida State) *Associate Professor of Meteorology*
 FRANK CLEMENTE, Ph.D. (Tennessee) *Professor of Sociology*
 RICHARD W. CLEVELAND, Ph.D. (California) *Professor of Plant Breeding*
 CLIFFORD C. CLOGG, Ph.D. (Chicago) *Assistant Professor of Sociology*
 HERMAN COHEN, Ph.D. (Iowa) *Professor of Speech Communication*
 SIDNEY COHN, Ph.D. (North Carolina) *Professor of Man-Environment Relations*
 CHARLES A. COLE, Ph.D. (Rutgers) *Professor of Engineering*
 GEORGE S. COLE, Ph.D. (Michigan State) *Assistant Professor of Management*
 HERBERT COLE, JR., Ph.D. (Penn State) *Professor of Plant Pathology*
 MILTON W. COLE, Ph.D. (Chicago) *Assistant Professor of Physics*
 RICHARD H. COLE, Ph.D. (Penn State) *Associate Professor of International Agronomy*
 MICHAEL M. COLEMAN, Ph.D. (Case Western Reserve) *Asst. Prof. of Polymer Science*
 CLARENCE H. COLLISON, Ph.D. (Michigan State) *Assistant Professor of Entomology Extension*
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 JOHN D. CONNOR, Ph.D. (Philadelphia) *Professor of Pharmacology*
 ROBERT A. CONOVER, Ph.D. (Lehigh) *Associate Professor of Engineering*
 JOSEPH C. CONWAY, Ph.D. (Penn State) *Associate Professor of Engineering Mechanics*
 DOUGLAS N. COOK, M.A. (Stanford) *Professor of Theatre Arts*
 JOHN A. COOK, M.F.A. (Iowa) *Professor of Art*
 EDWIN L. COOPER, Ph.D. (Michigan) *Professor of Zoology*
 RANIERO CORBELLETTI, M.S. (Columbia) *Professor of Architecture*
 SAM M. CORDES, Ph.D. (Washington State) *Assistant Professor of Agricultural Economics*
 ROGER N. CORNISH, Ph.D. (Minnesota) *Assistant Professor of Theatre and Film*
 PAUL R. CORNWELL, Ph.D. (Michigan) *Associate Professor of Psychology*
 THOMAS F. COSMIANO, Ph.D. (S.U.N.Y.) *Assistant Professor of Economics*
 ROBERT L. COWAN, Ph.D. (Penn State) *Professor of Animal Nutrition*
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 RICHARD CRAIG, Ph.D. (Penn State) *Associate Professor of Plant Breeding*
 LINDA W. CRAIGHEAD, Ph.D. (Penn State) *Assistant Professor of Education*
 W. EDWARD CRAIGHEAD, Ph.D. (Illinois) *Professor of Psychology*
 JOHN K. CRANE, Ph.D. (Penn State) *Associate Professor of English*
 CHARLES O. CRAWFORD, Ph.D. (Cornell) *Professor of Rural Sociology*
 DONALD M. CRIDER, Ph.D. (Penn State) *Associate Professor of Rural Sociology*
 WILLIAM E. CROCKEN *Associate Professor of Theatre Arts*
 LESLIE E. CROSS, Ph.D. (Leeds) *Professor of Electrical Engineering*
 KENNETH W. CROWLEY, Ph.D. (Brooklyn Polytechnic) *Professor of Civil Engineering*
 VIRGIL E. CROWLEY, Ph.D. (Missouri) *Professor of Farm Management Extension*
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 RICHARD G. CUNNINGHAM, Ph.D. (Northwestern), P.E. *Prof. of Mechanical Engineering*
 ROBERT L. CUNNINGHAM, Ph.D. (Washington State) *Prof. of Soil Genesis and Morphology*
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 ANTHONY CUTLER, Ph.D. (Emory) *Professor of Art History*
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 FRANK DACHILLE, Ph.D. (Penn State) *Professor of Geochemistry*
 SABIR H. M. DAHIR, Ph.D. (North Carolina State) *Associate Professor of Engineering*
 JOHN B. DALBOR, Ph.D. (Michigan) *Professor of Romance Languages*
 WILLIAM A. DAMERST, M.A. (Massachusetts) *Professor of English*
 MICHAEL C. DANAHY, Ph.D. (Princeton) *Associate Professor of French*
 JOHN D. DANIELS, Ph.D. (Michigan) *Professor of Business Administration*
 ROLAND R. DANIELS, Ph.D. (Wisconsin State) *Assoc. Prof. of Environmental Horticulture*
 STEVEN J. DANISH, Ph.D. (Michigan State) *Professor of Human Development*
 RONALD P. DANNER, Ph.D. (Lehigh) *Professor of Chemical Engineering*

- MUKUNDA B. DAS, Ph.D. (London), D.I.C. *Professor of Electrical Engineering*
 THOMAS E. DAUBERT, Ph.D. (Penn State) *Professor of Chemical Engineering*
 ANTHONY R. D'AUGELLI, Ph.D. (Connecticut) *Assoc. Professor of Human Development*
 ARTHUR B. DAUGHERTY, Ph.D. (Penn State) *Adj. Asst. Prof. of Agricultural Economics*
 JOHN R. DAUGHERTY, Ph.D. (Colorado State) *Asst. Prof. of Environmental Resource Mgmt.*
 EUGENE A. DAVIDSON, Ph.D. (Columbia) *Professor of Biological Chemistry*
 THOMAS B. DAVINROY, D.Eng. (California) *Associate Professor of Civil Engineering*
 ALAN DAVIS, Ph.D. (Durham) *Professor of Geology*
 DONALD D. DAVIS, Ph.D. (Penn State) *Associate Professor of Plant Pathology*
 JOHN W. DAVIS, Ph.D. (Penn State) *Assistant Professor of Industrial Engineering*
 SAMUEL G. DAVIS, Ph.D. (Syracuse) *Assistant Professor of Management Science*
 KATHRYN B. DE BOER, Ph.D. (Denver) *Associate Professor of Speech Communication*
 REGINALD A. DEERING, Ph.D. (Yale) *Professor of Biophysics*
 NED C. DEIHL, D.Ed. (Penn State) *Professor of Music Education*
 PETER DEINES, Ph.D. (Penn State) *Associate Professor of Geochemistry*
 GORDON F. DEJONG, Ph.D. (Kentucky) *Professor of Sociology*
 JAMES F. DELANSKY, Ph.D. (Cornell) *Associate Professor of Electrical Engineering*
 VLADIMIR DE LISSOVOY, Ph.D. (Cornell) *Prof. of Child Dev. and Family Relations*
 PAUL A. DE MAINE, Ph.D. (British Columbia) *Professor of Computer Science*
 LAURENCE M. DEMERS, Ph.D. (S.U.N.Y. Upstate Medical) *Assoc. Prof. of Pathology*
 WILLIAM E. DE MUTH, Jr., M.D. (Pennsylvania) *Professor of Surgery*
 NORMAN C. DENO, Ph.D. (Michigan) *Professor of Chemistry*
 ROSA G. DE PENNA, Ph.D. (Buenos Aires) *Professor of Meteorology*
 JACOB DE ROOY, Ph.D. (Rutgers) *Professor of Economics*
 PHILIP R. DESHONG, Sc.D. (M.I.T.) *Assistant Professor of Chemistry*
 WILLIAM R. DETAR, Ph.D. (Purdue) *Associate Professor of Agricultural Engineering*
 WAYNE L. DETWILER, D.Ed. (Penn State) *Assistant Professor of Vocational Education*
 FRANCINE DEUTSCH, Ph.D. (Penn State) *Asst. Prof. of Child Development and Child Services*
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 STEVEN DEUTSCH, Ph.D. (Penn State) *Res. Assoc. at Applied Research Laboratory*
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 CAROLYN R. DEXTER, Ph.D. (Columbia) *Asst. Professor of Social Science and Sociology*
 JONATHAN DICKINSON, Ph.D. (Michigan) *Assistant Professor of Economics*
 WARD S. DIETHORN, Ph.D. (Carnegie Tech.) *Professor of Nuclear Engineering*
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 JOSEPH A. DIXON, Ph.D. (Penn State) *Professor of Chemistry*
 JOHN J. DOCHERTY, Ph.D. (Arizona) *Associate Professor of Microbiology*
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 WILLIAM A. VOGELY, Ph.D. (Princeton) *Professor of Mineral Economics*
 BARRY VOIGHT, Ph.D. (Columbia) *Professor of Geology*
 ROY S. VOLLMER, M.Arch. (Pennsylvania) *Associate Professor of Architecture*
 MICHAEL VOLPE, Ph.D. (Temple) *Assistant Professor of Speech Communication*
 HELEN B. VOLZ, Ph.D. (Penn State) *Assistant Professor of Special Education*
 FRED W. VONDRACEK, Ph.D. (Penn State) *Associate Professor of Human Development*
 DONALD V. WADDINGTON, Ph.D. (Massachusetts) *Professor of Soil Science*
 JOHN S. WADE, JR., Ph.D. (Tennessee) *Associate Professor of Engineering*
 CLIFFORD H. WAGNER, Ph.D. (S.U.N.Y.) *Assistant Professor of Mathematics*
 JAMES S. WAKELEY, Ph.D. (Utah State) *Assistant Professor of Wildlife Ecology*
 DANIEL WALDEN, Ph.D. (New York) *Professor of American Studies*
 JOHN A. WALDHAUSEN, M.D. (St. Louis School of Medicine) *Professor of Surgery*
 PHILIP L. WALKER, JR., Ph.D. (Penn State) *Evan Pugh Professor of Materials Science*
 EDWARD J. WALSH, Ph.D. (Michigan) *Assistant Professor of Sociology*
 WALTER H. WALTERS, Ph.D. (Case Western Reserve) *Professor of Theatre Arts*
 HAROLD V. WALTON, Ph.D. (Purdue) *Professor of Agricultural Engineering*
 JAMES C. WAMBOLD, Ph.D. (New Mexico) *Assoc. Professor of Mechanical Engineering*
 MIAN-CHANG WANG, Ph.D. (California) *Associate Professor of Civil Engineering*
 PAUL J. WANGSNESS, Ph.D. (Iowa State) *Professor of Animal Nutrition*
 PATRICIA A. WARD, Ph.D. (Wisconsin) *Assoc. Prof. of French and Comparative Literature*
 WILBER W. WARD, D.For. (Yale) *Professor of Silviculture*
 ROGER P. WARE, Ph.D. (California) *Professor of Mathematics*
 REX H. WARLAND, Ph.D. (Iowa State) *Professor of Rural Sociology*
 THOMAS T. WARNER, Ph.D. (Penn State) *Assistant Professor of Meteorology*
 JOHN M. WARREN, JR., Ph.D. (Wisconsin) *Professor of Psychology*
 THOMAS WARTIK, Ph.D. (Chicago) *Professor of Chemistry*
 MICHAEL J. WASYLENKO, Ph.D. (Syracuse) *Assistant Professor of Economics*
 WILLIAM C. WATERHOUSE, Ph.D. (Harvard) *Professor of Mathematics*
 LOIS K. WATERS, Ed.D. (Columbia) *Assistant Professor of Nursing*
 THOMAS L. WATSCHKE, Ph.D. (Virginia Polytech.) *Assoc. Professor of Turfgrass Science*
 JAMES R. WATSON, Ph.D. (Illinois) *Associate Professor of Business Administration*

- ROBERT D. WEAVER, Ph.D. (Wisconsin) *Assistant Professor of Agricultural Economics*
 RALPH L. WEBB, Ph.D. (Minnesota) *Associate Professor of Mechanical Engineering*
 HELMUT E. WEBER, Sc.D. (M.I.T.) *Professor of Mechanical Engineering*
 DAVID L. WEBSTER, Ph.D. (Minnesota) *Associate Professor of Anthropology*
 FREDERICK C. WEDLER, Ph.D. (Northwestern) *Associate Professor of Biochemistry*
 DANIEL W. WEEDMAN, Ph.D. (Wisconsin) *Professor of Astronomy*
 PAUL D. WEENER, Ph.D. (Michigan) *Associate Professor of Educational Psychology*
 WILLIAM A. WEIDNER, M.D. (Wisconsin) *Professor of Radiology*
 WALTER B. WEIMER, Ph.D. (Minnesota) *Associate Professor of Psychology*
 FREDERICK F. WEINER, Ph.D. (Wayne State) *Associate Professor of Speech Pathology*
 STEVEN M. WEINRED, Ph.D. (Rochester) *Professor of Chemistry*
 STANLEY WEINTRAUB, Ph.D. (Penn State) *Research Professor of English*
 SUSAN F. WEIS, Ph.D. (Penn State) *Associate Professor of Home Economics Education*
 BORIS WEISFEILER, Ph.D. (Steklov's Math. Institute, Leningrad) *Assoc. Prof. of Mathematics*
 GERALD D. WEISMAN, Ph.D. (Michigan) *Assistant Professor of Man-Environment Relations*
 BENO WEISS, Ph.D. (New York) *Associate Professor of Italian*
 JUDITH WEISZ, M.B., B.Chir. (London) *Professor of Obstetrics and Gynecology*
 FREDERICK G. WELCH, D.Ed. (Penn State) *Associate Professor of Vocational Education*
 PAUL W. WELLIVER, Ph.D. (Penn State) *Professor of Education*
 ROBERT WELLS, Ph.D. (Princeton) *Associate Professor of Mathematics*
 WILLIAM A. WELSH, Jr., Ph.D. (Illinois) *Associate Professor of Civil Engineering*
 JANE I. WENGER, Ph.D. (Minnesota) *Assistant Professor of Physiology*
 NANCY WENTZLER, Ph.D. (Wisconsin) *Assistant Professor of Economics*
 FREDERICK L. WERNSTEDT, Ph.D. (U.C.L.A.) *Professor of Geography*
 HARRY H. WEST, Ph.D. (Illinois), P.E. *Associate Professor of Civil Engineering*
 PAUL N. WEST, M.A. (Columbia) *Professor of English and Comparative Literature*
 DAVID L. WESTBY, Ph.D. (Michigan State) *Associate Professor of Sociology*
 FRANCIS L. WHALEY, Ph.D. (Michigan) *Associate Professor of Psychology*
 ALFRED G. WHEELER, Jr., Ph.D. (Cornell) *Adjunct Assistant Professor of Entomology*
 ERIC R. WHITE, Ed.D. (Pennsylvania) *Affiliate Assistant Professor of Education*
 EUGENE E. WHITE, Ph.D. (Louisiana State) *Professor of Speech Communication*
 JOHN W. WHITE, Ph.D. (Penn State) *Professor of Horticulture*
 WILLIAM B. WHITE, Ph.D. (Penn State) *Professor of Geochemistry*
 WILLIAM J. WHITE, M.S. (Penn State) *Assistant Professor of Comparative Medicine*
 CAROL F. WHITFIELD, Ph.D. (George Washington) *Assistant Professor of Physiology*
 GEORGE D. WHITFIELD, Ph.D. (Columbia) *Associate Professor of Physics*
 JAMES O. WHITTAKER, Ph.D. (Oklahoma) *Professor of Psychology and Social Science*
 EDWARD W. WICKERSHAM, Ph.D. (Wisconsin) *Associate Professor of Biology*
 THOMAS A. WIGGINS, Ph.D. (Penn State) *Professor of Physics*
 KENNETH P. WILKINSON, Ph.D. (Mississippi State) *Professor of Rural Sociology*
 JACK H. WILLENBROCK, Ph.D. (Penn State), P.E. *Associate Professor of Civil Engineering*
 ANTHONY V. WILLIAMS, Ph.D. (Michigan State) *Associate Professor of Geography*
 ARTHUR L. WILLIAMS, Ph.D. (Pennsylvania), C.L.U. *Professor of Insurance*
 BRUCE A. WILLIAMS, Ph.D. (Minnesota) *Assistant Professor of Political Science*
 DAVID C. WILLIAMS, Ph.D. (Ohio State) *Assistant Professor of Education*
 EUGENE G. WILLIAMS, Ph.D. (Penn State) *Professor of Geology*
 FREDERICK M. WILLIAMS, Ph.D. (Yale) *Associate Professor of Biology*
 JANET A. WILLIAMSON, Ph.D. (Penn State) *Associate Professor of Nursing*
 SHERRY L. WILLIS, Ph.D. (Texas) *Assistant Professor of Early Childhood Education*
 FERN K. WILLITS, Ph.D. (Penn State) *Professor of Rural Sociology*
 DONALD J. WILLOWER, Ed.D. (Buffalo) *Professor of Education*
 BRENT G. WILSON, Ph.D. (Ohio State) *Professor of Art Education*
 DAVID T. WILSON, Ph.D. (Western Ontario) *Professor of Marketing*
 GEOFFREY L. WILSON, Ph.D. (Loughborough Tech., England), P.E. *Assoc. Prof. of Eng. Res.*
 LOWELL L. WILSON, Ph.D. (South Dakota State) *Professor of Animal Science*
 R. DALE WILSON, Ph.D. (Iowa) *Assistant Professor of Marketing*
 LOUIS WINKLER, Ph.D. (Pennsylvania) *Assistant Professor of Astronomy*
 NICHOLAS WINOGRAD, Ph.D. (Case Western Reserve) *Professor of Chemistry*

- JERRY L. WIRCENSKI, Ph.D. (Ohio State) *Associate Professor of Vocational Education*
 FRANCIS H. WITHAM, Ph.D. (Indiana) *Associate Professor of Biology*
 WILLARD E. WITTE, Ph.D. (Wisconsin) *Assistant Professor of Economics*
 WARREN F. WITZIG, Ph.D. (Pittsburgh) *Professor of Nuclear Engineering*
 JOACHIM F. WOHLWILL, Ph.D. (California) *Prof. of Man-Environment Relations and Psy.*
 GEORGE D. WOLF, Ph.D. (Pennsylvania) *Professor of American Studies and History*
 MELVIN H. WOLF, Ph.D. (Michigan) *Professor of Humanities and English*
 CARL H. WOLGEMUTH, Ph.D. (Ohio State) *Professor of Mechanical Engineering*
 FRED H. WOOD, D.Ed. (Missouri) *Professor of Education*
 NORMAN D. WOOD, Ph.D. (Brigham Young) *Assistant Professor of Education*
 ROBERT A. WOOD, Ph.D. (Pittsburgh) *Assistant Professor of Finance*
 DAWN CLAUDIA WOODERSON, Ph.D. (Florida State) *Assistant Professor of Music Education*
 LLOYD W. WOODRUFF, Ph.D. (Minnesota) *Associate Professor of Public Administration*
 PAUL O. WOOLLEY, JR., M.D. (Yale) *Associate Professor of Health Planning*
 J. RANDALL WOOLRIDGE, Ph.D. (Iowa) *Assistant Professor of Finance*
 DETLEF WOTSCHKE, Ph.D. (California) *Assistant Professor of Computer Science*
 HELEN S. WRIGHT, Ph.D. (Penn State) *Associate Professor of Nutrition*
 JAMES E. WRIGHT, JR., Ph.D. (Cornell) *Professor of Genetics*
 LAUREN A. WRIGHT, Ph.D. (California Tech.) *Professor of Geology*
 PAUL J. WUEST, Ph.D. (Penn State) *Professor of Plant Pathology*
 LAKSHAM S. YAPA, Ph.D. (Syracuse) *Associate Professor of Geography*
 RONALD E. YASBIN, Ph.D. (Rochester) *Asst. Professor of Microbiology and Cell Biology*
 THOMAS D. YAWKEY, Ph.D. (Illinois) *Associate Professor of Education*
 WILLIAM G. YENDOL, Ph.D. (Purdue) *Professor of Entomology*
 EDGAR P. YODER, Ph.D. (Ohio State) *Assistant Professor of Agricultural Education*
 BERTRAM YOOD, Ph.D. (Yale) *Professor of Mathematics*
 THOMAS M. YORK, Ph.D. (Princeton) *Professor of Aerospace Engineering*
 CARL E. YOUNG, Ph.D. (George Peabody) *Assistant Professor of Human Development*
 DAVID L. YOUNG, M.L.A. (Harvard) *Professor of Landscape Architecture*
 PHILIP YOUNG, Ph.D. (Iowa) *Research Professor of English*
 IAN S. ZAGON, Ph.D. (Colorado) *Assistant Professor of Anatomy*
 CARLOS ZAMORA, Ph.D. (U.C.L.A.) *Assistant Professor of Spanish*
 SAM Y. ZAMRIK, Ph.D. (Penn State) *Professor of Engineering Mechanics*
 ARIAN ZARKOWER, Ph.D. (Cornell) *Associate Professor of Veterinary Science*
 PAUL A. ZAWADZKI, Ph.D. (Iowa) *Assistant Professor of Speech Communication*
 WILBUR ZELINSKY, Ph.D. (California) *Professor of Geography*
 ROBERT F. ZELIS, M.D. (Chicago) *Professor of Medicine and Physiology*
 JOHN H. ZIEGLER, JR., Ph.D. (Penn State) *Professor of Meat Science*
 VICKIE L. ZIEGLER, Ph.D. (Yale) *Associate Professor of German*
 LEONARD N. ZIMMERMAN, Ph.D. (Cornell) *Professor of Bacteriology*
 RICHARD E. ZINDLER, Ph.D. (Michigan State) *Professor of Engineering Research*
 GEORGE S. ZORETICH, M.A. (Penn State) *Professor of Art*

GENERAL INFORMATION

THE GRADUATE SCHOOL

Graduate work at The Pennsylvania State University was first offered in 1862, but for some time there were few graduate students and graduate instruction was relatively unorganized. A committee of the General Faculty eventually was given the responsibility of establishing standards and regulations governing graduate work and the granting of master's and certain technical degrees. The Graduate School was formally established in 1922 by the President and the Board of Trustees. An administrative staff was organized, and the Graduate Faculty was formed. The University Senate delegated to this faculty responsibility for graduate affairs, subject to review. In 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy. On May 9, 1971, a Graduate Council was established for the Graduate School. Today graduate study is offered in 124 major programs, with 17 advanced academic and professional degrees being conferred. During the academic year 1978-1979, 5,800 to 6,200 graduate students were enrolled each term, and 1,752 advanced degrees were conferred, of which 383 were doctorates.

The Graduate School is a member of the Association of Graduate Schools (an organization within the Association of American Universities) and of the Council of Graduate Schools in the United States.

MAJOR ROLE

The major role of the Graduate School is to emphasize those aspects of University activity which pertain directly to major programs in graduate study. Through its Graduate Faculty it represents a large segment of the academic strength of the University and is thus a dominant force in sustaining and furthering the intellectual quality of the entire institution. The eleven colleges of the University formulate study and research programs appropriate to their fields. The Graduate Faculty consists of those members of the college faculties who have authorization through the Graduate School to offer courses and seminars and supervise research and theses consistent with the highest academic standards. Thus, the Graduate School may be regarded as a federation of selected segments of the college faculties.

GOVERNANCE

The governance of the Graduate School is vested in a Graduate Council, whose legislative authority is subject to the specific restrictions of the "Articles of Authority." The council forms its own committee structure under bylaws outlined in "Standing Rules of the University Graduate Council."

Executive and administrative matters of the Graduate School are the responsibility of the dean, who is charged directly with enforcement of the regulations of the Graduate School and with organization of its administrative procedures. The dean has a major responsibility to enhance and insure the high quality of graduate study and research of graduate students. He exercises leadership in initiating new programs and in restructuring or phasing out marginal and obsolete ones. The dean encourages and assists in the development of multidisciplinary programs. He is assisted in this work by an administrative and clerical staff.

ADMINISTRATIVE DIVISIONS

There are four major administrative divisions in the Graduate School to which the students may go directly for answers to questions which require administrative assistance or decisions:

1. *Graduate Admissions*, 201 Kern Graduate Building. The Office of Graduate Admissions has responsibility for processing all matters pertaining to a student's admission.
2. *Graduate Student Programs*, 211 Kern Graduate Building. The functions of the Office of Graduate Student Programs encompass responsibilities for the academic involvement and concerns of all graduate students from the time they are admitted until they graduate, such as: (a) registration of students, (b) readmission of students, (c) maintenance of records, (d) appointment of graduate committees for doctoral students, (e) scheduling of graduate student comprehensive examinations, (f) checking for accomplishment by students of Graduate Fac-

ulty requirements for all advanced degrees and preparation of official commencement lists, and (g) attention to student academic problems.

3. *Graduate Fellowships*, 320 Kern Graduate Building. The Office of Graduate Fellowships serves as a clearinghouse for information on available fellowships and other awards for graduate students, administers fellowships and other award programs involving students in more than one college, and seeks support for graduate students attending the University.
4. *Theses and Publications*, 320 Kern Graduate Building. The Office of Theses and Publications is responsible for reviewing all theses to assure that they meet format requirements consistent with the attainment of high scholarly standards. The office prepares the major Graduate School publications.

PROGRAMS AT OTHER LOCATIONS

Behrend College — The Behrend College at Erie provides convenient opportunity for graduate education to persons residing in northwestern Pennsylvania. It has been established to offer individual courses and a program leading to the degree of Master of Engineering with a major in engineering science.

Radnor Center for Graduate Studies — The Radnor Center for Graduate Studies near Philadelphia offers programs leading to the degrees of Master of Engineering with majors in engineering science and industrial engineering, and Master of Education with a major in mathematics.

The Capitol Campus — The Capitol Campus, located near Middletown and named for its proximity to the state capital, was opened in 1966. Graduate programs leading to the degrees of Master of Administration, Master of Arts with majors in American studies and in humanities, Master of Education with a major in teaching and curriculum, Master of Engineering with a major in engineering science, Master of Psychosocial Science, Master of Public Administration, and Master of Regional Planning with a major in urban and regional planning are currently offered.

The Milton S. Hershey Medical Center — The University's Medical Center was established in 1963, and the first class of medical students entered in the fall of 1967. The center is located in Hershey, Pennsylvania, twelve miles from Harrisburg. In conjunction with The Pennsylvania State University's Graduate School, the College of Medicine offers programs leading to the Master of Science degree with a major in laboratory animal medicine, and to the Doctor of Philosophy and Master of Science degrees with majors in anatomy, biological chemistry, microbiology, pharmacology, and the intercollege programs in genetics and physiology.

KERN GRADUATE BUILDING

The Kern Graduate Building is named in honor of the late Dean Emeritus Frank D. Kern, who was the first dean of the Graduate School. The Graduate School administrative offices are on the second and third floors of the building.

GRADUATE COMMONS

The Graduate Commons, located on the first floor of Kern Graduate Building, provides programs, services, and facilities for the graduate community and serves as a common meeting area for faculty and

students. The assembly room and multipurpose rooms are used for large group meetings; the smaller rooms are used for committee meetings and similar small group gatherings. These may be reserved by graduate organizations or for events of a University-wide nature.

Food service is provided by the Department of Housing and Food Service in the cafeteria and for special catered events. The lobby contains the Commons Gallery, which displays artwork done by students and faculty and exhibits from sources outside the University. The Commons serves as the home for Graduate Student Association programs such as the coffeehouse, films, concerts, and similar events. Policy governing building use and services is determined by the Graduate Council Committee on Graduate Commons and Related Matters.

The Office of the Director of the Graduate Commons serves as a clearinghouse for the scheduling of events planned by organizations and individuals. Reservations, a periodicals lending library (including daily newspapers), information regarding Graduate Commons activities, recreational equipment, and information of a general nature concerning the Graduate School are available at the Graduate Commons Information Desk. The Commons is open seven days a week during the term session. The operating hours are posted at building entrances. For further information call the Information Desk at 865-1878.

INTERNATIONAL STUDENT AFFAIRS

The Office of International Student Affairs (OISA) and the International Student Lounge are located in 111 Kern Graduate Building. There are approximately 1,200 international students from 100 countries studying at the various University campuses. The majority of these students are enrolled in graduate programs.

Services of OISA include: assistance with immigration regulations and tax information; academic, financial, and personal/social counseling; emergency loans; program advising; mail service; housing information; job and travel information; job information in home countries; an international student newsletter; and sponsorship of many clubs and activities.

The International Student Lounge is a comfortable place for international and American students to meet informally. All students are welcome to participate in OISA activities. Announcements of events are posted regularly in the lounge. OISA maintains a library of overseas work/study/travel information, as well as other educational reading materials, including dictionaries, encyclopedias, maps, arts and crafts books, and many newspapers and magazines from around the world. The lounge and conference room are available for group meetings upon request.

The OISA works closely with the Community International Hospitality Council, a local community volunteer organization, and the International Council, a student organization which represents international students to the University administration and promotes a variety of social, cultural, and educational programs for the University community.

GRADUATE STUDENT ASSOCIATION

The Graduate Student Association was established in 1951 as the representative body for graduate students, all of whom are automatically members, and is charged with designating graduate student representatives to a number of committees throughout the University. This volunteer organization provides graduate students with services, programs, and activities not otherwise available through the University. It also provides occasions for relaxation through its social programs. To help defray expenses, the association is partially funded through an allocation from Associated Student Activities, which is under the direction of the assistant vice president for student programs.

The Graduate Student Association Council, the legislative arm of the association, consists of elected delegates from every graduate department, with voting rights proportionate to the number of students in the department. Also included as voting *ex officio* members are the graduate students who have been elected to serve on the University Faculty Senate (4), the Graduate Council (5), and the University Council (1). All members of the University community are invited to attend the regular monthly meetings of the Association Council. An Executive Board, which consists of the executive officers and di-

vision heads, has interim powers to conduct business not requiring the specific action of the Association Council. The executive officers act as official liaison between the association and the dean of the Graduate School.

The Graduate Student Association has established the following divisions and standing committees: *Service Division* (1) Housing Committee, (2) Publication Committee, (3) Health Committee, and (4) Tax Committee; *Programming/Planning Division* (1) Coffeehouse Committee, (2) Film Committee, (3) Speakers and Workshop Committee, and (4) Special Events Committee; *Academic Division*: (1) Rules Committee, (2) Research and Advocacy Committee, and (3) Nominating Committee.

In addition, the Association Council may institute *ad hoc* committees and presidential commissions at will. Graduate students are eligible to serve on all committees of the Graduate Council.

The association maintains communication among its members through the campus daily newspaper, scheduled meetings and workshops, and informal use of the Graduate Commons. It publishes annually the *Guide to Graduate Life*, an informal introduction to both the University and the community.

The Graduate Student Association office is at 305 Kern Graduate Building (Tel. 865-9061). Graduate students are encouraged to bring any questions about graduate life to the office for informative, informal conversation.

FACILITIES

THE UNIVERSITY LIBRARIES

The University Libraries include a central collection, four subject branch libraries, and one reading room at University Park. Libraries are also located at Hershey Medical Center, Capitol Campus, Sadnor Graduate Center, Behrend College, and at each of the seventeen two-year campuses.

At University Park, the central collection, the Arts Library, and the Life Sciences Library are all housed in the Fred Lewis Pattee Library. There are four branch libraries serving the Colleges of Earth and Mineral Sciences, Engineering, Science, and the Department of Mathematics; one reading room in the Department of Architecture; and the Pollock Library in an undergraduate dormitory area.

Included in the central collection are general reference books and periodicals, works in agriculture, biology, education and psychology, economics and business, the humanities, the natural and social sciences, maps, manuscripts, and government documents. Among special collections are the Penn State Collection, a Joseph Priestley and a John O'Hara Collection, labor history archives, Audio Archives Collection, Australiana and Utopian literature, the Allison-Shelley Collection of Anglica Americana Germanica, music cassettes, microforms, and a rare book collection. Housed in Pattee Library is the Penntap Information System, which serves industries, municipalities, and businesses in the Commonwealth. In the reading room and special branch libraries are books and journals needed for work assigned in the Colleges mentioned above. A library handbook for students is available at the Information Desk on the main floor of Pattee. Several courses in Library Studies are offered each year by the faculty. In addition, a program of library instruction includes sessions provided as a part of regularly scheduled University courses in cooperation with the course instructors, and topical seminars by library faculty. General library orientation tours are offered at the beginning of each term. Computerized literature searches of selected data bases in engineering, earth and mineral sciences, and in the physical, social, and life sciences are available through the General Reference Section and the related branch libraries.

The University Libraries are a member of numerous cooperative groups. They are one of the four Regional Library Resource Centers as established by Pennsylvania law and have memberships in the Union Library Catalogue of Pennsylvania, the Association of Research Libraries, the Mid-Atlantic Research Libraries Information Network, the Associated College Libraries of Central Pennsylvania, and the Pittsburgh Regional Library Center.

The libraries have approximately 2,280,000 catalogued volumes, 998,000 government documents, 23,500 serials, 215,000 maps, 2,000,000 microforms, 2,928 music cassettes, and over 2,000,000

other bibliographical items. Among the special resource guides issued by the library are *Newspapers in Microform*, *Pennsylvania Maps and Atlases*, *Serial Holdings in The Pennsylvania State University Libraries at University Park*, *Guide to Sources in Black Studies in The Pennsylvania State University Libraries*, *Voices and Events*, a catalogue of audio tapes recorded on the University Park Campus, and the University Libraries Bibliographical Series. Newsletters from the General Reference and Microforms Sections provide up-to-date information on the Libraries' resources and services.

COMPUTATION CENTER

The Computation Center is actively engaged in evaluating and developing modern computing trends and computer systems to meet current job and research needs. Organized as a separate unit under the University Intercollege Programs, the Computation Center provides computing tools and technical services that aid in the education and research programs of all academic departments. Its facilities are heavily used by more than 4,000 graduate students and faculty engaged in research, and by 10,000 undergraduate students doing class assignments; the Computation Center routinely processes more than 15,000 separate computer jobs per day. Computer hardware includes a modern six-megabyte IBM 3033 Processor Complex, about three billion bytes of disk storage, a ten-thousand-reel tape library, and a large configuration of other input/output and telecommunications equipment. Current computer software includes a large repertoire of modern programming language compilers and several thousand library programs. There are sixty-five machine-readable data bases available, including 300 magnetic tape volumes of census data. Access to the computer system can be obtained through high-speed batch terminals (ten on campus, and twenty-two at the two-year colleges). Typewriter terminals may also access the computer system through either the APL time-sharing facility, the Penn State Remote Job Entry file system, or INTERACT/WYLBUR. Except for a few holidays, the Computation Center is open for job processing twenty-four hours a day, seven days a week.

The Computation Center faculty and staff conduct group tours, computer programming workshops, technical seminars, and guest lectures to acquaint the University community with the services available and with advances in computing practices. Computation Center programming consultants provide advice and technical assistance for using library programs, and advice for programming and debugging new applications. Extensive documentation in all areas of related service and programming is provided for graduate students and faculty. The Computation Center offers assistantships to qualified graduate students enrolled in any curriculum. A more detailed summary of facilities and services may be found in the publication *Introduction to the Computation Center*, available in 214 Computer Building.

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus and within comfortable walking distance of most of the campus, provide one- and two-bedroom apartments for graduate students with families.

The Eastview Terrace apartments are fire-resistant, steel-framework, one-story buildings. There are forty-six one-bedroom units and thirty two-bedroom units. Rent includes utilities except for electricity, telephone, and TV cable. Water is heated electrically. The units are unfurnished except for electric stove and refrigerator. For each two units, there is a utility room with two stationary laundry tubs and storage space. Privately owned automatic washers may be installed in apartment kitchens only. No coin-operated facilities are available.

Graduate Circle has 144 one-bedroom apartments and 72 two-bedroom apartments in sixteen two-story buildings of brick and frame construction. Rent includes all utilities except for telephone. Each kitchen has a double stainless steel sink with disposal unit, a gas stove, kitchen cabinets, and an electric refrigerator. One bedroom has a built-in chest of drawers; otherwise, the units are unfurnished. There are no facilities for private washing machines in the apartments; however, ticket-operated laundries at nominal fees are provided in five of the buildings throughout the area. A basement storage locker is provided for each apartment.

Residence in Graduate Circle or Eastview Terrace Graduate Family Apartments is limited to registered full-time graduate students who are candidates for advanced degrees. All students must live with their spouse and/or preschool children in the apartment. Families with children of school age (including kindergarten) or with children who will come of school age during the term of the lease cannot be considered for occupancy. The one-bedroom units are designed for a graduate student and spouse, and the two-bedroom units for a family with not more than two children. Rates and additional information can be obtained from the Assignment Office for Campus Residences, 101 Shields Building, University Park, PA 16802. Telephone: (814) 865-7501

Atherton Hall, located near the Hetzel Union Building, and McKee Hall, located near the Kern Graduate Building, are residence halls which provide combined room and board accommodations for single graduate men and women. Most assignments are made to double rooms since single rooms are available for only one out of three students. Rates for room and board for these halls can be obtained from the Assignment Office.

All rates are subject to change by action of the University.

Information on other living accommodations available in the community may be obtained through:

The Graduate Student Association
305 Kern Graduate Building
The Pennsylvania State University
University Park, Pennsylvania 16802
Phone: (814) 865-9061

The Organization of Town Independent Students
20 Hetzel Union Building
The Pennsylvania State University
University Park, Pennsylvania 16802
Phone: (814) 865-6851

The State College Area Chamber of Commerce
131 Sowers Street
State College, Pennsylvania 16801
Phone: (814) 237-7644

Graduate students should arrange for their accommodations well in advance of the beginning of classes; because it may be very difficult to find convenient housing at the last minute. **STUDENTS MUST BE ADMITTED TO THE GRADUATE SCHOOL BEFORE THEIR REQUESTS FOR ON-CAMPUS LIVING ACCOMMODATIONS CAN BE PROCESSED.**

STUDENT SERVICES

The facilities and services outlined in the following paragraphs are available to graduate students.

UNIVERSITY HEALTH SERVICES

Located in the central campus area, the Ritenour Health Center is the core of the health service activities and is composed of a dispensary and a hospital. Its facilities are available to full-time graduate students qualifying for nonacademic student benefits and privileges; that is, students registered for 6 or more credits or the equivalent (students holding quarter-time, half-time, or three-quarter-time assistantships.) *The outpatient dispensary handles student medical problems from 8:00 a.m. until 4:45 p.m. daily except Saturdays, when hours are from 8:00 a.m. to 11:45 a.m. During other periods, including Sundays and holidays, patients are seen for emergencies only in the Emergency Room of the University Hospital, which is part of the Health Center complex. There is a \$7.50 emergency charge per visit.

The University Hospital is well equipped to handle the more serious illnesses and injuries on an inpa-

tient basis. A twenty-five-bed facility, it is staffed with professional personnel twenty-four hours a day during the school terms. Should the need arise for special medical or surgical treatment — major surgery, for example — the student will be transferred to a personally chosen hospital facility.

Included in the Health Center facilities are a dental office for emergency dental care, a physiotherapy department, a pharmacy, and a nutrition clinic.

Hospitalized students will be charged \$45 per day during confinement, and a nominal charge will be made for X-rays and all drugs dispensed to hospital or dispensary patients. Consultation with or treatment by physicians other than the professional staff at the Health Center is at the student's expense. All accounts should be settled before the end of the term in which charges were incurred.

The Ritenour Health Center maintains an ambulance service for local transportation of students with nonambulatory illnesses and injuries.

HEALTH INSURANCE

Comprehensive, low-cost medical insurance is available for full- and part-time graduate students and their dependents. Information concerning the specifics of the policy can be obtained by contacting the Graduate Student Association, 305 Kern Graduate Building, University Park, PA 16802 (Tel. 865-4211).

MEDICAID BENEFITS

Graduate students may qualify for most of the benefits that apply to hospitalization and medical treatment under Medicaid. Graduate students who are permanent residents of Centre County may apply for state medical assistance to the Office of the Centre County Board of Assistance, Bellefonte, PA 16823 (Tel. 355-5531).

HEALTH SERVICES FOR CHILDREN

Many medical services are available for children under twenty-one through the State Health Center. The services range from simple immunizations to complicated surgery. Diagnostic study and consultation at the center are made regardless of the ability to pay; however, not all services are free. Children may be referred to the center by physicians or health and welfare agencies. Any preschool child is eligible for free well-child examinations and immunizations. For additional information, contact the Health Center at 110 South School Street, Bellefonte, PA 16823 (Tel. 355- 5438), or consult your doctor.

CAREER DEVELOPMENT AND PLACEMENT CENTER

The center functions as both a counseling and placement service for students. Its primary purpose is to serve students, both individually and in groups, by assisting them through career and educational counseling in formulating immediate and long-range career plans.

The center cooperates with the colleges and departments of the University to assist students in implementing career plans upon graduation. Services include: (1) a library containing information on career opportunities, employer characteristics, and graduate and professional schools; (2) scheduled interviews with prospective employers who are visiting the campus; (3) a file of employment opportunities for which a student may apply by mail; (4) a listing of career-related summer jobs and internships; (5) workshops in interviewing skills, résumé preparation, and looking for a job; (6) a variety of informational meetings and publications; and (7) credential services for candidates seeking positions in educational institutions.

*Eligibility is determined by the Graduate School when the I.D. cards are issued.

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

University Park Campus and Medical Center (Nonmedical Students) — 8 or more credits, total charge of \$583 for Pennsylvanians and \$1,166 for non-Pennsylvanians; 7 or fewer credits, \$73 per credit for Pennsylvanians and \$146 for non-Pennsylvanians. These rates apply also to off-campus research and other approved individual study.

Behrend College, Radnor Graduate Center, and Capitol Campus — 8 or more credits, total charge of \$531 for Pennsylvanians and \$1,166 for non-Pennsylvanians; 7 or fewer credits, \$61 per credit at Behrend, \$67 per credit at Radnor and Capitol, for Pennsylvanians; \$146 per credit at all locations for non-Pennsylvanians.

Continuing Education Center — Tuition for continuing education courses carrying graduate credit will be charged at the prevailing rate at the campus where the courses are offered.

Vocational Education Program — 8 or more credits, total charge of \$583 for Pennsylvanians and \$1,166 for non-Pennsylvanians; 7 or fewer credits, \$73 per total program for Pennsylvanians and \$146 for non-Pennsylvanians (vocational education courses are indicated by "v" following the course number).

Tuition is the same for courses whether audited or taken for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of \$25. A student whose account is delinquent for more than ten days is subject to suspension from the University.

When it appears that an applicant for admission is not domiciled in Pennsylvania, a non-Pennsylvanian classification is assigned. If the student who is thus admitted believes that circumstances do not justify classification as a non-Pennsylvanian, a petition can be made to the Financial Officer for the Dean of the Graduate School, 316 Kern Graduate Building, University Park, PA 16802, for reclassification. (See Student Pennsylvania Resident Status, page 62.)

All tuition costs are subject to change.

TUITION REFUND POLICY

Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the Office of Graduate Student Programs and presents it, together with a current Certificate of Registration, at the Office of the Fee Assessor no later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term, in accordance with the following schedule:

Refund of 80 percent upon withdrawal before the end of the first week of the term (seventh consecutive calendar day from the first day of classes) and a decrease of 20 percent for each week thereafter, up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIFIC CHARGES

In addition to the foregoing tuition and charges, the following charges apply under special conditions and are to be paid independently:

Application fee	\$20.00
Change of schedule	6.00
Duplicate meal ticket	2.00
Duplicate student identification and activity card	each 5.00

Music, individual lessons.....	40.00 to 100.00
Privilege of late payment.....	25.00
Privilege of late registration	10.00
Special Ph.D. thesis preparation registration fee (601, 611)	128.00
Student parking fee, each term.....	10.00
Teacher placement service registration fee	10.00
Teacher placement service reactivation fee	10.00
Thesis microfilming and binding fee for master's candidate (one copy).....	12.50
Thesis microfilming and binding fee for doctoral candidate (one copy).....	40.00
Transcript of records (with seal), each copy	2.00
Mailing diploma in absentia.....	5.00

A student's transcript, diploma, or both, may be withheld until any outstanding financial obligations to the University have been paid.

MOTOR VEHICLE CHARGES

Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) while at the University is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no registration charge for students who do not desire campus driving or parking privileges. Failure to register a vehicle renders a student liable for a fine of \$15 for each offense or a magistrate's citation.

A permit allowing limited driving and parking on the campus throughout the week costs \$10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only \$3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles. A graduate assistant receiving no fee decals must present a valid driver's license and the owner's card for the vehicle each term. Pennsylvania registration of all motor vehicles is required if the student lives for more than thirty consecutive days of the year in Pennsylvania. A student's spouse may be required to register his or her car in Pennsylvania. A *Student Parking and Traffic Regulations* booklet is available in Room 209, Hetzel Union Building.

Bicycles — A bicycle is defined as a two-wheeled vehicle propelled by human power. All bicycles operated on the University Park Campus or in the surrounding community must be registered once each year. Expiration date is May 31. Registration may be obtained at the Department of University Safety, 12 Grange Building, Monday through Friday between 8:00 a.m. and 5:00 p.m. Rules and regulations are available at the time of registration.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if acceptance is indicated before April 15, will have complete freedom through April 15 to submit in writing a resignation of the appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits the student to not accept another appointment without first obtaining a formal release.

Selection of recipients of all University awards is made without regard to the sex, race, religious belief, or ethnic origin or handicap or age of the applicant, as provided by law.

ASSISTANTSHIPS

Approximately 2,200 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some major pro-

grams. An appointee may serve as an assistant in classroom or laboratory instruction, in research, or in other work.

A prospective student should write directly to the person in charge of the intended graduate major program for information and application forms. Appointments are made subject to the student's admission to the Graduate School as a degree candidate. Clear evidence of superior ability and promise is required. Reappointment to an assistantship is based on availability of positions and the quality of the student's work. In most departments or major programs the number of appointment renewals is limited. A common policy is to limit eligibility to two calendar years of study for a master's candidate or five total years for a doctoral candidate.

The assistantships vary as follows:

QUARTER-TIME—The student normally schedules 7-9 credits per term, receives a stipend in the range \$196-300 per month plus a grant-in-aid of resident education tuition, and is assigned tasks requiring a maximum of 120 hours per term (e.g., ten hours of effort per week for twelve weeks).

HALF-TIME—The student normally schedules 5-7 credits per term, receives a stipend in the range \$392-600 per month plus a grant-in-aid of resident education tuition, and is assigned tasks requiring a maximum of 240 hours per term (e.g., twenty hours of effort per week for twelve weeks).

THREE-QUARTER-TIME—The student normally schedules 4-5 credits per term, receives a stipend in the range \$588-900 per month plus a grant-in-aid of resident education tuition, and is assigned tasks requiring a maximum of 360 hours per term (e.g., thirty hours of effort per week for twelve weeks).

The credit load limits specified above may be increased or decreased for a specific term by permission of the assistantship supervisor, provided the total work load is properly balanced in each term and the total credit load over a series of terms is in conformity with the specified limits stated above. Work assigned as a part of assistantship duties for which academic credit is granted need not be counted as a part of the credit limits stated above.

In addition to receiving a grant-in-aid to cover tuition during the term of appointment, a graduate assistant completing three or more consecutive terms of appointment is entitled to a grant-in-aid of tuition for the immediately succeeding term if a scholarship or fellowship is not received from another source for the term. To receive this privilege a student must obtain an Earned Extra Grant-in-Aid Form from the head of the department or program in which the assistantship was held and must follow the instructions on the form in making application.

A graduate assistant may accept concurrent employment outside the University only with permission from the assistantship department head and the assistant's graduate academic program chairman. Concurrent employment normally may not be held with the University. A student may receive a concurrent fellowship supplement.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS AND TRAINEESHIPS

About three hundred fellowships and traineeships are awarded annually. Recipients must be superior students and are sometimes required to have completed a certain minimum of graduate work before being eligible for an award. Need is also frequently a consideration. Fellows and trainees are required to carry 8-10 credits of course work each term or the equivalent in research, receive stipends which vary with the awards, and usually receive grants-in-aid of tuition. They may not accept employment during the terms of their appointments (except with special permission for training purposes) nor are they required to render any service to the University. In some cases a recipient will be expected to engage in research in a broad field specified by the donor. There is no sharp distinction between a fellowship and a traineeship. Scholarly excellence is always a major consideration and usually the most important criterion in selecting fellowship recipients. Other considerations commonly come first in awarding traineeships.

GRADUATE SCHOOL FELLOWSHIPS — A number of fellowships, each paying a stipend of up to \$508/month and providing a grant-in-aid to cover resident education tuition charges, are given by the University and are designated as Graduate School Fellowships. They are available to outstanding graduate students working toward a Ph.D., D.Ed., or M.F.A. degree. The ability of applicants being

comparable, some preference is given to students majoring in the humanities and social sciences.

Application forms may be obtained from the Graduate School Fellowship Office, 320 Kern Graduate Building. Applications must be submitted through the applicant's graduate major program and must be received by the Graduate School by the first Monday in February to be considered for the following year. Graduate Record Examination verbal, quantitative, and analytical test scores are required of all applicants.

ERIC A. WALKER AND SPECIAL GRADUATE SCHOOL FELLOWSHIPS, FELLOWSHIP SUPPLEMENTS, AND GRANTS-IN-AID — These are open only to students who have been approved for admission but are not yet enrolled in the Graduate School at the time of application. Full fellowships pay up to \$508/month plus resident education tuition. Grants-in-aid provide only tuition. Supplements are small grants in addition to a graduate assistantship or another fellowship. Some supplements are in the form of low-interest loans. Application forms may be obtained from the Fellowship Office, 320 Kern Graduate Building, University Park, PA 16802, and must be submitted through the person in charge of the applicant's graduate major program so as to reach the Graduate School by mid-February to be considered for the following fall. Applicants must arrange to have Graduate Record Examination verbal, quantitative, and analytical test scores sent to the Graduate School by the application deadline.

MINORITY GRADUATE SCHOLARS AWARDS — These are fellowships, assistantships, and fellowship supplements granted as a part of the University's comprehensive educational opportunity program. Stipends and qualifications are the same as for other fellowships and assistantships. For further information contact the Graduate School Fellowship Office, 320 Kern Graduate Building.

FELLOWSHIPS AND TRAINEESHIPS FROM SPECIFIC GRANTS TO DEPARTMENTS AND DIVISIONS BY FOUNDATIONS, INDUSTRIAL CONCERNS, AND FEDERAL AGENCIES — Over 200 such awards, with various stipends, are granted through individual departments and state and national organizations. Information and application forms may be secured from the person in charge of the appropriate graduate major program. The specific awards will vary somewhat from year to year, but the following are typical of those which were available for 1979-80.

ADMINISTRATION ON AGING TRAINEESHIPS — Available to graduate students admitted for study in selected programs; stipend varies. Details available from the Gerontology Center, S-211 Henderson Human Development Building.

AMAX, INCORPORATED FELLOWSHIP — Available to a graduate student in Metallurgy; stipend \$5,280.

AMELIA EARHART FELLOWSHIP — Available to a woman graduate student in Aerospace Engineering; stipend \$4,000.

AMERICAN ACCOUNTING ASSOCIATION FELLOWSHIP — Available to a Ph.D. candidate in accounting; stipend variable up to \$3,000.

AMERICAN CHEMICAL SOCIETY FELLOWSHIP — Available to a graduate student in Solid State Science; stipend \$6,204 plus tuition and fees.

AMERICAN CHEMICAL SOCIETY FELLOWSHIPS (2) — Open to graduate students in Geochemistry, Mineralogy, and Solid State Science; stipend \$2,400.

AMERICAN INSTITUTE OF CERTIFIED PUBLIC ACCOUNTANTS FELLOWSHIP — Available to a Ph.D. candidate in accounting; stipend variable up to \$7,800, to \$8,400 with dependents.

AMERICAN PSYCHOLOGICAL ASSOCIATION MINORITY PROGRAM FELLOWSHIPS — Students apply to the Department of Psychology, 417 Moore Building.

ARTHUR ANDERSON & CO. CONSTRUCTION MANAGEMENT FELLOWSHIP — Available to a graduate student in Civil Engineering to support the study phase of his or her graduate work study program in construction management; stipend \$6,000.

ARTHUR ANDERSON & CO. FOUNDATION FELLOWSHIP — Available to a Ph.D. candidate in accounting; stipend variable up to \$7,800.

ASARCO FOUNDATION FELLOWSHIP — Available to a graduate student in Mineral Economics who is interested in writing his or her thesis on nonfuel mineral products, particularly those produced by the donor; stipend \$2,719.

BECHTEL POWER CORPORATION POWER PLANT CONSTRUCTION MANAGEMENT FELLOWSHIP — Avail-

- able to a graduate student in Civil Engineering to support the study phase of his or her work study program in power plant construction management; stipend \$2,400.
- BISMUTH INSTITUTE FELLOWSHIP** — Available to graduate students in Solid State Science, stipend \$5,712 plus tuition and fees.
- CONTINENTAL OIL COMPANY FELLOWSHIP** — Available to a graduate student in Petroleum and Natural Gas Engineering for studies in petroleum engineering; stipend variable.
- CONTINENTAL OIL COMPANY FELLOWSHIP IN PETROLEUM ECONOMICS** — Available to a graduate student in Mineral Economics for studies in petroleum economics; stipend \$1,950.
- COOPERS & LYBRAND FOUNDATION FELLOWSHIP** — Available to a Ph.D. candidate in accounting; stipend variable, up to \$5,000.
- WHEELER P. DAVEY MEMORIAL FELLOWSHIPS** — Available to graduate students in physics; stipend variable.
- DOLomite BRICK CORPORATION GRADUATE FELLOWSHIP** — Available to a graduate student in ceramic science and engineering for research on the thermal/mechanical behavior of dolomite refractories; stipend \$4,000 plus tuition.
- W. S. ELLIOTT FELLOWSHIP** — Available to a graduate student who is a graduate of The Pennsylvania State University and is interested in engineering research; stipend variable. Apply to Office of the Dean, College of Engineering, 101 Hammond Building.
- ERNST and WHINNEY FELLOWSHIP** — Available to a master's candidate in accounting; stipend \$1,000; to a Ph.D. candidate with stipend up to \$7,800.
- EXCHANGE TEACHING FELLOWSHIPS IN FRANCE (English Conversation)** — At the University of Strasbourg and the University of Lyon, October-June, renewable. Available to graduate students in French; stipend approximately \$4,700.
- HERMAN G. FISHER GRADUATE FELLOWSHIP** — Available to an advanced graduate student in Human Development and Family Studies and especially interested in work with young children; stipend \$5,000 for tuition and other expenses. Apply to the Graduate Program in Human Development and Family Studies.
- GENERAL FOODS FUND FELLOWSHIPS (2)** — Open to graduate students with a major in the College of Human Development or in Home Economics Education; stipend for doctoral \$3,000, for master's \$2,000, for tuition and other expenses.
- GULF OIL COMPANY FELLOWSHIP IN PETROLEUM AND NATURAL GAS ENGINEERING** — Available to a graduate student for work in petroleum production; stipend variable.
- JAMES HAMILTON HARTZELL and LUCRETIA IRVINE BOYD HARTZELL HISTORY AWARD** — Available to graduate students in History whose field of interest is Pennsylvania history; stipend variable.
- HASKINS and SELLS FOUNDATION FELLOWSHIP** — Available to a graduate student in accounting; stipend \$2,500.
- WALTER E. HELLER FELLOWSHIP** — Provided by Walter E. Heller & Company, in the amount of \$1,000 for a candidate for the degree of Master of Business Administration.
- HILL FELLOWSHIPS FOR STUDY IN ANTHROPOLOGY OR HISTORY** — Details available from Dean S.F. Paulson of the College of the Liberal Arts, 108 Sparks Building.
- IBM FELLOWSHIP** — Available to graduate students in Solid State Science; stipend \$5,400 plus tuition and fees.
- INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION FELLOWSHIP** — In support of research on the physics and chemistry of lead and zinc compounds. Available to a student in Solid State Science; stipend \$2,540.
- JOSEPH M. JOHNSTON MEMORIAL SCHOLARSHIP** — Available to a student whose program is related to floriculture; stipend variable. Apply through the Department of Horticulture.
- SAMUEL H. KRESS FOUNDATION** — Makes available travel grants and research stipends for American students in art history, architecture, and conservation; for doctoral candidates only.
- MICASU SCHOLARSHIP** — Available to a graduate student in Animal Industry who has financial need and who has demonstrated academic achievement and improvement during the graduate program; stipend \$600.
- MUSEUM INTERNSHIPS** — Available to graduate students in American Studies at the Capitol Campus; stipend varies. Apply to Professor Irwin Richman, Professor in Charge of the Graduate Program in American Studies, Capitol Campus.
- NATIONAL INSTITUTE OF AGING TRAINEESHIPS** — Available to doctoral students in selected graduate

- programs for research training in adult development and aging; stipend varies. Details available from the Gerontology Center, S-211 Henderson Human Development Building.
- NATIONAL STEEL CORPORATION FELLOWSHIP** — Available to a graduate student in Metallurgy; stipend \$5,280.
- MRS. A. ROBERT NOLL GRADUATE FELLOWSHIP IN APPLIED PHYSIOLOGY** — For graduate research in applied physiology; especially in environmental or exercise physiology; stipend variable.
- OWENS-CORNING FELLOWSHIP** — Available to a graduate student in the Geochemistry and Mineralogy graduate program; stipend variable, up to \$6,000.
- OWENS-ILLINOIS FELLOWSHIP** — Available to a graduate student in Ceramic Science whose thesis is in the area of glass science and technology; stipend \$4,000.
- P.P.&L. POWER PLANT CONSTRUCTION MANAGEMENT GRANT** — Available to a graduate student in Civil Engineering to support a portion of the study phase of a student's graduate work study program with P.P.&L; stipend \$2,500.
- PENNSYLVANIA MEAT PACKERS' ASSOCIATION SCHOLARSHIP** — Open to a selected graduate student specializing in meat science; stipend \$600. Apply through the Department of Dairy and Animal Science.
- PRICE WATERHOUSE FOUNDATION FELLOWSHIP** — Available to a Ph.D. candidate in accounting; stipend variable up to \$5,000.
- ALEXANDER PROUDFOOT FELLOWSHIP IN EDUCATIONAL PSYCHOLOGY** — Available to a student with a strong interest in and aptitude for applying his or her skills in measurement to the problems of human performance in work situations; stipend \$3,600 plus tuition. Apply to Admissions Committee Chairman, Graduate Program in Educational Psychology, 403 Carpenter Building.
- JESSE ROSSITER RAPP MEMORIAL SCHOLARSHIP** — Available to graduate students in the School of Forest Resources who are not holding assistantships as graduate students. Apply to the School of Forest Resources' Scholarships, Loans, and Awards Committee.
- RCA CORPORATION FELLOWSHIP** — Available to a graduate student in Electrical Engineering; stipend \$2,500-3,000 for nine months. May be supplemented for an additional three months on application.
- RESCO FELLOWSHIP** — Available to a graduate student in Ceramic Science for research on phosphate-bonded alumina; stipend \$5,000.
- FRED B. ROONEY TRANSPORTATION SCHOLARSHIP** — Established by the Seley Foundation and available to a graduate student in Civil Engineering who is a permanent resident of either Lehigh or Northampton County, Pennsylvania, and who is specializing in transportation engineering. Apply to the Department of Civil Engineering, 212 Sackett Building.
- SHAEFFER SCHOLARS PROGRAM** — Provided by Charles W. Shaeffer ('33), retired board chairman, T. Rowe Price Associates, to M.B.A. candidates evidencing strong academic and managerial potential; stipend \$4,000. Apply to director of M.B.A. program.
- J. WALDO SMITH HYDRAULIC FELLOWSHIP** — Established by the American Society of Civil Engineers, Board of Direction, for a graduate student who is preferably an associate member of ASCE. Awarded every third year; \$2,000 for one full academic year, plus a maximum of \$1,000 for research equipment, preferably in the field of experimental hydraulics. More information can be obtained from the Department of Civil Engineering, 212 Sackett Building.
- EDWIN ERLE SPARKS DISSERTATION FELLOWSHIP IN THE HUMANITIES** — Available to a doctoral candidate in one of the following graduate programs: Classics, Comparative Literature, English, French, German, History, Linguistics, Philosophy, Religious Studies, Slavic Languages and Literatures, Spanish, and Speech Communication; stipend \$4,800 plus tuition. Apply to relevant department or program before February 1.
- EDWIN ERLE SPARKS FELLOWSHIPS IN THE HUMANITIES (8)** — Available to beginning graduate students in one of the following graduate programs: Classics, Comparative Literature, English, French, German, History, Linguistics, Philosophy, Religious Studies, Slavic Languages and Literatures, Spanish, and Speech Communication; stipends \$3,800 plus tuition. Apply to relevant department or program before February 1.
- TAU BETA PI FELLOWSHIP** — Open to any member of Tau Beta Pi, the engineering honor society, for a year of advanced study. Up to 18 awards of \$3,500 each are available. Applications and information may be obtained from the Office of the Dean, College of Engineering, 101 Hammond Building. Application deadline is February 15.
- TEXACO FELLOWSHIP IN EARTH AND MINERAL SCIENCES** — Available to a graduate student in the

- College of Earth and Mineral Sciences; stipend \$1,200-3,000 plus tuition.
- WALTER THOMAS MEMORIAL SCHOLARSHIP** — Available to a student studying the nutrition of horticultural crops; stipend variable. Apply through the Department of Horticulture.
- HARRY F. THOMSON SCHOLARSHIP** — Established by the American Concrete Institute for graduate study in the field of concrete. The scholarship is open to any student who is completing studies toward the bachelor's degree or who has received a bachelor's degree from an accredited engineering program. The applicant must be accepted for graduate study of concrete, involving design, materials, construction, or any combination of these subject areas, at a recognized university or college at the time of the award. Information and applications may be obtained from the Department of Civil Engineering, 212 Sackett Building. Application deadline is February 1.
- U.S. OFFICE OF EDUCATION BILINGUAL EDUCATION FELLOWSHIPS** — Available to Ph.D. and D.Ed. candidates preparing for professional careers in bilingual education or a related field; stipend \$3,000-4,700 plus dependency allowance, tuition, books, and fees. Apply to Director, Bilingual Education Program, Division of Curriculum and Instruction, College of Education.
- U.S. OFFICE OF EDUCATION FELLOWSHIPS IN SPEECH PATHOLOGY AND AUDIOLOGY: WORK WITH THE SPEECH-HANDICAPPED; WORK WITH THE DEAF** — Open to graduate students specializing in these fields; stipend up to \$1,200-2,400. Apply to the Communication Disorders Program.
- U.S. OFFICE OF EDUCATION PUBLIC SERVICE FELLOWSHIPS** — Available through the Institute of Public Administration at the University Park Campus and the MPA Program at the Capitol Campus; a stipend of \$3,900 for twelve months and tuition. Fellowships are awarded only to students in the Master of Public Administration degree programs at the Capitol Campus and the University Park Campus.
- U.S. OFFICE OF EDUCATION TRAINEESHIPS IN THERAPEUTIC RECREATION (28)** — Open to graduate students being prepared as leadership personnel in special education; stipend \$300-600 per term plus tuition. Graduate assistantships also available. Apply to the Graduate Admissions Committee, 327 CEDAR Building.
- U.S. OFFICE OF EDUCATION TRAINEESHIPS IN SPECIAL EDUCATION** — Open to graduate students specializing in therapeutic recreation; stipend \$2,250 (three terms). Apply through the Graduate Program in Recreation and Parks.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN CLINICAL PSYCHOLOGY (10)** — Available through the Department of Psychology; stipend \$2,925 for nine months plus tuition.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN NURSING** — Open to selected registered nurse students in nursing; stipend \$3,900 plus tuition. Apply to Professor in Charge, Graduate Program in Nursing.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN NUTRITION IN PUBLIC HEALTH** — Available to selected students in public health nutrition; stipend \$5,000, plus tuition, for 12 months. Apply to the Graduate Program in Nutrition.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN RESEARCH ON LIFE SPAN DEVELOPMENT AND THE FAMILY** — Open to selected post-master's graduate students in Human Development and Family Studies who are interested in research on the mental health aspects of individual and family development; stipend \$3,900. Apply to Graduate Program in Human Development and Family Studies.
- U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN SOCIAL GERONTOLOGY (12)** — Open to selected post-master's graduate students in the social and behavioral sciences; stipend \$5,025. Apply to Director, Program in Adult Development and Aging, S-110 Henderson Human Development Building.
- U.S. REHABILITATION SERVICES ADMINISTRATION TRAINEESHIPS IN SPEECH PATHOLOGY AND AUDIOLOGY (7)** — Open to graduate students specializing in speech pathology and audiology and hearing impaired; stipend up to \$2,400-4,100. Apply to the Communication Disorders Program.
- U.S. REHABILITATION SERVICES ADMINISTRATION TRAINEESHIPS IN THERAPEUTIC RECREATION** — Open to graduate students specializing in therapeutic recreation; stipend \$1,800 (three terms). Apply through the Graduate Program in Recreation and Parks.
- VETERANS ADMINISTRATION INTERNSHIPS IN CLINICAL PSYCHOLOGY** — A limited number of internships in veterans administration agencies (hospitals and clinics) are available to graduate students in clinical psychology upon direct application to the agency's chief psychologist with endorsement by the Department of Psychology. Stipend variable.
- ARTHUR YOUNG AND COMPANY FELLOWSHIP** — Open to a master's degree candidate in accounting from a predominantly black college. Contact the department in the College of Business Administration.

In addition, grants are available from governmental agencies, industrial concerns, foundations, and the armed forces for graduate study and frequently for support of investigations of particular problems. Some of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from the department of specific interest.

EXTERNALLY SPONSORED FELLOWSHIP AND TRAINEESHIP PROGRAMS — Attention is directed to the following national programs, involving numerous fields of study, with which the University cooperates by providing local administration. (See Statement of Nondiscrimination, page 60.)

FEDERAL HIGHWAY ADMINISTRATION FELLOWSHIPS — Provided by the Federal Highway Administration, U.S. Department of Transportation, to develop the expert manpower needed to carry out state and local jurisdiction highway programs. Open to qualified students for graduate study in traffic engineering and other highway-related areas. Only U.S. citizens are eligible. Fellowships are granted for an academic year at \$6,000 each for tuition, books, and living stipends. Application forms are available from the National Highway Institute, U.S. Department of Transportation, Washington, D.C. 20590.

INTERNATIONAL UNIVERSITY FELLOWSHIPS IN SPACE SCIENCE — These graduate and postdoctoral fellowships are available to foreign nationals who hold the equivalent of Master of Science or Master of Engineering degrees and meet graduate student entrance requirements at United States universities. Details on the program will be found in the brochure concerning these fellowships issued by the Office of Scientific Personnel, National Academy of Sciences, Washington, D.C. 20418.

NATIONAL SCIENCE FOUNDATION FACULTY FELLOWSHIPS — The Graduate School coordinates a program of awards to young college and university teachers (U.S. citizens only) wishing further training or research experience. Awards are made for all or part of a year or for a succession of summer terms. Stipends are related to current academic salary. Application materials may be obtained from the National Science Foundation, Washington, D.C. 20550. The application deadline for 1980 was November 29, 1979.

NATIONAL SCIENCE FOUNDATION GRADUATE FELLOWSHIPS AND MINORITY GRADUATE FELLOWSHIPS — The Graduate School cooperates in this program of prestige fellowships requiring outstanding credentials. These fellowships are available in the biological, engineering, mathematical, physical, and social sciences, as well as the history and philosophy of science. Application is made during the fall to the Fellowship Office, National Academy of Sciences, National Research Council, 2101 Constitution Ave., N.W., Washington, D.C. 20418, which has charge of evaluating applicants for the foundation. The stipend is \$325 per month for three years plus remission of tuition. The application deadline for 1980 was November 29, 1979.

U.S. OFFICE OF EDUCATION MINING AND MINERAL AND MINERAL FUEL CONSERVATION FELLOWSHIPS — Available to individuals in appropriate majors working for M.S. or Ph.D. degrees who are U.S. nationals. Thirty-eight fellowships were awarded in 1978. Award is based on need, significance of planned research, and academic promise. Stipend is \$325 per month. Application procedures are the same as for Graduate School Fellowships. Awards may be supplemented by additional support.

U.S. ENVIRONMENTAL PROTECTION AGENCY FELLOWSHIPS — Available to graduate students who are working in the area of air or water pollution control or potable water production and who are employed by a governmental pollution control agency. Application materials are available from the Grants Administration Division (PM-216), Environmental Protection Agency, Washington, D.C. 20460.

OTHER AIDS

GRADUATE SCHOOL TUITION GRANTS-IN-AID — About forty grants of tuition remission for full-time study are awarded each term. They are available to any graduate degree candidate in the third or later term at the University on criteria of financial need and academic promise. A recipient must carry 8 to 10 credits of graduate work but may accept employment of not more than ten hours per week with the University or another employer. Applications for grants for the winter, spring, and summer terms must be filed by the beginning of the fifth week of the preceding term and by mid-April for the fall term. Application forms may be obtained from the Graduate School Fellowship Office, 320 Kern Graduate Building.

THE RUTH YOUNG BOUCKE GRADUATE FELLOWSHIP — Established from the estate of Ruth Young Boucke, whose husband was for many years a professor of economics, this fellowship is available every other year to an outstanding graduate student on the same basis as the regular Graduate School fellowships, and selection is made by the Graduate School Committee on Fellowships and Awards. The stipend is up to \$508/mo. plus a grant-in-aid of the \$128 thesis preparation fee.

EMPLOYMENT AND LOAN PROGRAMS — Any prospective or current graduate degree candidate may seek aid from loan and employment programs directly through the Office of Student Aid, 335 Boucke Building.

To be considered for the aid programs listed below, a prospective graduate student must

1. file a Financial Aid Form (FAF), a document used to assess a student's financial need, with the College Scholarship Service, Box 176, Princeton, NJ 08540. (The GAPFAS needs analysis form used at some institutions is not accepted by the Office of Student Aid.)
2. file an Application for Financial Aid and a Financial Aid Transcript with the Office of Student Aid. For each postsecondary institution the student has attended at which he or she has received financial aid, a separate Financial Aid Transcript, certified by that institution, must be submitted. All such transcripts must be received by the Office of Student Aid before any funds can be dispersed and before processing of a Guaranteed Student Loan (described below).

THE FACULTY AIDE PROGRAM is a form of federal aid awarded to graduate students with documented financial need who wish to earn a portion of their aid eligibility through part-time employment. In 1979-80, Faculty Aides received \$6.00 per hour for assisting faculty and administrators in their research, instructional, and administrative duties. Responsibilities and assignments are similar to those associated with graduate assistantships. Earnings may not exceed the documented need determined for the applicant. This type of aid is not recommended for a student who accepts a graduate assistantship because one of the conditions of the assistantship may prohibit additional employment.

THE NATIONAL DIRECT STUDENT LOAN PROGRAM is a low-interest loan available to United States citizens and permanent residents with a documented financial need, as determined from the Financial Aid Form. Repayment is not necessary until after graduation or termination of graduate work. A schedule of payments will be arranged at that time. Interest begins to accrue nine months after graduation or termination at the rate of 3 percent per year simple interest. Maximum loan for one year is \$2,500.

UNIVERSITY LOANS are funds established by University organizations, alumni, faculty, staff, and friends to help students who have a documented financial need. The borrower is not expected to repay until after graduation or termination of study. Interest begins to accrue immediately upon graduation or termination of study at a 6 percent per year simple interest rate. Maximum loan for one year is \$2,000.

THE GUARANTEED STUDENT LOAN PROGRAM provides low-interest loans (7 percent simple interest per annum) to students enrolled on at least a half-time basis. The loans are repayable after the student graduates or terminates his or her education. This federal financial aid program is a cooperative effort of the federal government, state government and/or guarantor agency, a commercial lending institution, and the educational institution.

An application, including the Lender's Report, should be obtained from a lending institution which agrees to participate with the student in this program. The loan is available on an interest-free basis to all students during their graduate enrollment, regardless of family income. While enrolled, a student's interest payments on the outstanding loan principal are paid by the federal government. A graduate student may borrow up to a total of \$15,000, including any Guaranteed Student Loans received for undergraduate study. Maximum loan for one year is \$5,000.

Additional information for prospective graduate students may be obtained from the Office of Student Aid, 335 Boucke Building, University Park, PA 16802. In corresponding with this office, specify that you are a current or prospective graduate student, and if the latter, the term you wish to begin graduate study at the University.

When seeking aid, the prospective student should keep in mind the following:

Cost of Attendance — In determining a student's need in 1979-80, the Office of Student Aid used the following estimates of expenses for an academic year (three terms) as a basic guide. (Estimates are increased for students with dependents.)

Tuition	\$1,581	(In 1979-80, tuition at
Room & Board	1,665	Behrend, Capitol, and
Books	240	Radnor was \$1,440;
Miscellaneous	1,383	tuition for non-
Total Estimated Costs	\$4,869	Pennsylvanians at all
		locations was \$3,150.)

Nondegree Students — Financial aid is available for graduate students who are degree candidates only. Nondegree graduate students are not eligible for assistance.

Summer Term Financial Aid — Students who wish to apply for financial aid for a summer term must file a separate summer Application for Financial Aid with the Office of Student Aid, even if the student received, or will receive, aid for the fall-winter-spring academic year.

The following loans are available only to students in specific graduate programs.

THE U.S. ENVIRONMENTAL PROTECTION AGENCY SPECIAL AIR POLLUTION LOAN FUND has been established through the University's Center for Air Environment Studies. Recipients must be in the terminal year of their program and pursuing a career in air pollution control. Repayment must be completed within three years of graduation. Interest accrues at an annual rate of 3 percent. If the recipient works for two years following graduation for an air pollution control agency, no repayment is required. Apply through the Center for Air Environment Studies.

THE UNITED STATES STEEL FOUNDATION LOAN FUND provides loans for emergencies and to supplement fellowships. Recipients must be U.S. citizens who are enrolled full-time in graduate programs in the colleges of Earth and Mineral Sciences, Engineering, or Science. Further information may be obtained from the Graduate School Fellowship Office, 320 Kern Graduate Building.

GIRARD EDU-CHECK PLAN — The University offers to sponsors (including parents) of students the Assured Education Plan, enabling them to pay out of current income, on a monthly basis, University bills for tuition, residence hall room and board, and all other items billed by the University. Life insurance and total and permanent disability insurance are a part of the plan for the sponsor up to the sixty-eighth and sixty-first birthdays, respectively. Payments are handled through the Girard Bank, 1339 Chestnut Street, Philadelphia, PA 19107. Further information and application forms may be obtained from the Office of the University Bursar, 103 Shields Building. Signed agreements should be received well in advance of registration, since it takes at least three weeks for completion of arrangements.

STUDENT EMPLOYMENT — Many students depend upon part-time employment to help meet their expenses. Students who are thus employed, however, must recognize the time demands of their work schedules and will be required to adjust their academic loads accordingly. The Office of Student Employment, 322 Boucke Building, offers assistance in finding part-time employment in town, as well as on campus. This office also provides the student with assistance in finding summer employment. The Office of Student Aid coordinates the Faculty Aide program, described above under Loan and Employment Programs.

Local placement services and the University Office of Personnel maintain files of positions open to spouses of students. Many area residents seek help for babysitting, housework, typing, and other general kinds of employment.

A student holding a fellowship or traineeship may not accept employment of any kind for service without special advance approval. A graduate assistant may accept concurrent employment outside the University only after obtaining permission from the department head and person in charge of the major program. Concurrent appointments with the University other than a Fellowship Supplement normally may not be held.

VETERANS' BENEFITS — The Coordinator of Veterans Affairs has the responsibility of handling all applications for benefits under the various Public Laws. Veterans who intend to enroll at the University should contact the Veterans Outreach Office, 135 Boucke Building, University Park, PA 16802, as far in advance as possible to obtain information and necessary forms. The Outreach Office also provides information on other programs and services unique to veterans.

Under P.L. 89-358, a student is entitled to benefits if registered full time for 8 or more credits, unless the department head certifies that fewer credits constitute a full-time academic load for that student (see Full-Time Academic Status, p. 67).

At each registration, a special veterans (V) card must be submitted to confirm enrollment and academic status. Submission of this card does not generate benefits which are not already certified, but failure to submit the card results in immediate interruption of VA benefits.

Veterans in their first term may defer tuition and room and board fees until their benefit checks begin to arrive.

Federal law and Veterans Administration Regulations specify the conditions under which veteran students and eligible dependents are paid VA educational benefits. Veterans Administration benefits are paid under the standards of academic progress and policies relating to student conduct contained in this bulletin and which apply to all graduate students. In addition, certain special conditions for payment of VA educational benefits must be met:

1. Courses which do not meet graduation requirements in the student's approved major (the major which the student has declared to the VA) cannot be computed as part of the student's course load for payment of VA benefits.
2. Unless mitigating circumstances exist, VA benefits cannot be paid for attendance of any portion of a course or term that is not completed.
3. Regardless of academic standing, any veteran student or eligible dependent who fails, or records a combination of failures and withdrawals, in all courses attempted during a term must be reported to the Veterans Administration for lack of satisfactory progress.
4. Unless *specific documentation* of an identifiable professional or academic goal can be provided (e.g., teachers requiring 24 graduate credits to obtain permanent certification), no veteran or eligible dependent may be certified for payment of VA educational benefits for any term subsequent to one during which he or she accumulates 12 credits on a nondegree status.
5. Since a 3.0 cumulative grade-point average is required for graduation, graduate student veterans and eligible dependents will be warned that their VA educational benefits may be suspended if their cumulative grade-point average falls below 3.0 during any given term. If the student's average remains below 3.0 for a second consecutive term, the VA Certifying Official will request a determination of whether progress has been satisfactory from the appropriate department head. If it has not, the VA Certifying Official will suspend benefits and report the veteran to the VA for lack of satisfactory progress.
6. Veterans and eligible dependents must report any change in academic status (change of credit load, change of major, etc.) to the Office of Veterans Affairs or other appropriate VA Certifying Official promptly and personally.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth here in the *Graduate Degree Programs* catalog and in the *Thesis Information Bulletin*, and for meeting the standards and requirements expressed by these regulations. Copies of the graduate catalog are available from the Graduate Commons Information Desk, 113 Kern Graduate Building; the *Thesis Information Bulletin* can be obtained from the Office of Theses and Publications, 320 Kern Graduate Building. Graduate students are encouraged to contact the Office of Graduate Student Programs, 211 Kern Graduate Building (Tel. 865-1834), for guidance if they have any questions, uncertainties, or difficulties concerning any procedure or regulation of the Graduate School or any procedure or regulation of the University as it may affect them.

STATEMENT OF NONDISCRIMINATION

The Pennsylvania State University, in compliance with federal and state laws and regulations governing affirmative action and nondiscrimination, does not discriminate in the recruitment, admission, and employment of students, faculty, and staff in the operation of any of its educational programs and activities as defined by law. Accordingly, nothing in this publication should be viewed as directly or indirectly expressing any limitation, specification, or discrimination as to race, religion, color, or national origin; or to handicap, age, sex, or status as a disabled or Vietnam-era veteran, except as provided by law. Inquiries concerning this policy may be directed to the Vice President for Student Affairs.

ADMISSION

Each step of the educational process, from admission through graduation, requires continuing review and appropriate approval by University officials. The University, therefore, reserves the right to change the requirements and regulations contained in this bulletin and to determine whether a student has satisfactorily met its requirements for admission or graduation, and to reject any applicant for admission for any reason the University determines to be material to the applicant's qualification to pursue higher education.

An applicant for admission to the Graduate School should understand that graduate work is not a simple extension of an undergraduate program but, rather, demands scholarship of a higher order, and emphasizes research, creativity, and professional competence with a minimum of formal requirements and a maximum of student initiative and responsibility.

Objective — The objective of the Graduate School is to admit a qualified graduate student body up to the limit of the University's resources to provide outstanding graduate programs. In general, a student may begin graduate work in fall, winter, spring, or summer.

Applicants must recognize that staff, facilities, and other resources are limited, so that not all qualified persons can be admitted. The number accepted will vary by program, and from term to term. In some graduate programs all vacancies will have been filled long before the general Graduate School deadline for submitting applications, so that even outstanding students cannot be accepted.

Application — Applicants interested in graduate programs offered at University Park or The Milton S. Hershey Medical Center should apply to University Park. Those interested in programs at the Capitol Campus, the Radnor Center for Graduate Studies, or Behrend College should apply directly to the appropriate campus. Students are normally expected to begin work at the campus to which they are admitted.

Qualifications — For admission to the Graduate School, an applicant must have received from an accredited institution, a baccalaureate degree earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. Ordinarily, an entering student must have completed in a satisfactory manner a minimum of course work in designated areas, the specific courses and amount of work depending upon the field of advanced study. All applicants must submit Graduate Record Examination Aptitude Test scores. Individual graduate programs and departments may require Advanced Test scores.

A baccalaureate degree holder with a slight deficiency in undergraduate preparation may be admitted and allowed to schedule a limited number of undergraduate courses to remove the deficiency while proceeding in the graduate program. Courses taken for this purpose do not apply toward the requirements of the advanced degree.

Admission may be granted to applicants whose credentials are not complete at the time of application because the baccalaureate degree has not yet been conferred, grades for the current term are not yet available, GRE scores have not yet been reported, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission is canceled for any reason, the student is thereby automatically dropped from the Graduate School.

Admission is granted jointly by the Graduate School and the department or graduate program in which the student plans to study. The establishment of standards by which applicants are admitted is a departmental or program responsibility. Although the Graduate School has no fixed minimum grade-point requirement for admission, an applicant is generally expected to maintain a junior-senior grade-

point average of at least 2.50 on The Pennsylvania State University grading scale of A (4) to D (1). Individual programs may establish higher grade-point average requirements and use other criteria to judge candidates for admission. In exceptional cases, departments or major programs may also approve admission by reason of special backgrounds, abilities, and interests. Departmental or program requirements are given in the descriptive statements appearing under the major programs listed in the latter part of this publication.

A student who has been admitted to a program in which the doctorate is offered may begin working toward that degree but has no official status as a doctoral student and no assurance of acceptance as a doctoral candidate until a candidacy examination administered by the major department or committee has been passed.

Forms — Application forms may be obtained from the Office of Graduate Admissions. Applicants may apply for admission to only one program at a time. All academic records, including an explanation of the grading system used, should be submitted, *in duplicate*, to the Office of Graduate Admissions, 201 Kern Graduate Building. These must be received from all institutions by the Graduate School at least one month prior to the opening of the term in which the student plans to begin a graduate program.

Deadlines — The deadline for processing of applications by the Graduate School is one month prior to the beginning of any given term. **GRADUATE MAJOR PROGRAMS MAY REQUIRE EARLIER DEADLINES.** A complete Graduate School admissions file, which is required for processing an application, includes the following items: (1) application form, (2) application fee form, (3) a check or money order in the amount of \$20.00 made payable to The Pennsylvania State University, and (4) duplicate transcripts from each institution of higher education attended. Supplementary materials and examination scores may be required in individual programs. If the admission file is incomplete a month prior to the beginning of the term for which the student has applied, the materials will be processed for the first term following the completion of the admissions file.

Nondegree — A student who plans to take courses for transfer to another institution or to follow a program of study not leading to an advanced degree at this institution should apply for admission as a nondegree student. The adviser for such a student may be appointed by the department head or program chairman most closely associated with the student's field of interest. The number of nondegree students which can be admitted is limited because preference is given to students in degree programs.

Minority Students — Minority students are encouraged to apply for admission to any of the programs offered in the Graduate School. Information concerning programs and financial aid may be obtained from the chairman of the graduate program or the dean of the college of the student's major interest.

International Students — International students should plan to apply at least six months prior to the beginning of the term in which they intend to begin graduate studies. They must submit, *in duplicate*, certified English translations of all academic records. In addition, all international students whose native language is not English must take the TOEFL (Test of English as a Foreign Language) and submit the results of this test with the application for admission. A student must present a minimum TOEFL score of 525 to be considered for admission. International students who have been admitted to graduate study with TOEFL scores of 550 or higher will be considered to have met the Graduate School's English language proficiency requirement. International students who have been admitted with TOEFL scores below 550 will be scheduled for diagnostic testing and assigned appropriate remedial work to improve their English language proficiency. Such students will demonstrate that they meet the established English language proficiency requirement by retaking the TOEFL and achieving a score of at least 550. Under ordinary circumstances, it is expected that the master's candidate will demonstrate proficiency during the first or second term of graduate study. Doctoral candidates who have been admitted with TOEFL scores below 550 must retake the TOEFL and achieve a score of at least 550 before they are admitted to candidacy for the degree. Information about the TOEFL can be obtained by writing to the Educational Testing Service, Box 899, Princeton, NJ 08541. Like other applicants, international students must submit Graduate Record Examination scores. International students are not admitted as nondegree students unless such admission is requested by a sponsoring agency. Nondegree students must also fulfill the Graduate School English language proficiency requirement.

UNDERGRADUATE STUDENTS — A student of The Pennsylvania State University who is within three credits of completing the baccalaureate degree may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade-

point average of 3.00). Any senior with a 3.50 grade-point average may be admitted to 500-level courses with the consent of the instructor; other students of at least tenth-term standing with a B average or better may be admitted to such courses with the consent of the instructor, the student's academic adviser, and the associate dean of the Office of Graduate Student Programs.

In certain cases undergraduate students may subsequently apply credits they have earned in 400- and 500-series courses toward an advanced degree at The Pennsylvania State University. Upon admission to the Graduate School, and with the approval of the major field, those credits *relevant* to the graduate program of study which were not used to satisfy undergraduate requirements may be applied toward an advanced degree. The time limitation on the completion of a master's degree program applies to these, as well as to other, credits.

GUESTS OF THE UNIVERSITY — It is the policy of the Graduate School not to permit applicants to work for a second doctoral degree. The President, on recommendation of the dean of the Graduate School, will welcome, as guests, holders of earned doctoral degrees who may be visiting the University Park Campus for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the dean of the Graduate School.

STUDENT PENNSYLVANIA RESIDENT STATUS — When it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that the applicant is a non-Pennsylvanian. If a student who is thus admitted believes that the circumstances do not justify classification as a non-Pennsylvanian, a written petition for reclassification may be filed with the Financial Officer of the Graduate School, 316 Kern Graduate Building, University Park, PA 16802. Capitol Campus students may petition the Capitol Campus Financial Officer.

A copy of the *Policy for Determination of Students' Pennsylvania Resident Status* can be obtained in the Office of the Financial Officer mentioned above. Under the rules of this document, when a written petition for reclassification is made, the petitioner is required to present proof of bona fide domicile within the Commonwealth or such other evidence as is pertinent to a complete review of the student's classification. Upon review, a decision by the highest designated authority at the University shall constitute an exhaustion of administrative remedies.

Any reclassification resulting from a student's challenge shall be effective for tuition purposes as of the date such challenge was filed. A student who changes domicile from Pennsylvania to another state must promptly give written notice to the University.

CLASSIFICATION OF STUDENTS

A graduate student may be admitted either as a degree student or as a nondegree student, depending upon the student's objectives. After admission to one of these categories, any change to the other must be arranged through the Office of Graduate Student Programs.

DEGREE STUDENTS — A degree student is one who plans to become a candidate for an advanced degree at The Pennsylvania State University and who has been formally admitted for advanced studies in a particular program. The program of study is developed under the guidance of an adviser appointed by the head of the student's major program. A degree student who has passed a candidacy examination is classified as a doctoral candidate.

NONDEGREE STUDENTS — An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced degree at this institution, may arrange for a program of work as a nondegree student. This classification includes students who plan to transfer credits to another institution and those who plan special programs of study not leading to an advanced degree. The number of nondegree students who can be admitted is limited, and it is increasingly difficult to provide for them because of the limitation of resources. Preference is given to students in degree programs.

Nondegree students who are applying for admission to the University Park Campus *must* submit two transcripts from each institution attended. Transcripts should be sent to the Office of Graduate Admissions, 201 Kern Graduate Building, The Pennsylvania State University, University Park, PA 16802.

The admission of a nondegree graduate student at the University Park Campus will be subject to the recommendation of the program chairman or head of the department of the student's primary interest and proposed area of work. Casual students with broad interests not easily identifiable with a single program may be admitted directly by the Graduate School. Applications and credentials must be received at least one month prior to the anticipated term of enrollment. A maximum of 12 credits earned as a nondegree student may be applied to a degree program.

UNDERGRADUATE NONDEGREE STUDENTS — Such a student is not a graduate student since a baccalaureate degree has not been earned. The student may not register for graduate courses or research (500 and 600 series) without permission from the Office of Graduate Student Programs. A student having attained junior standing in college may register for 400-level courses and is admitted through undergraduate admissions.

PROGRAMS

MAJOR PROGRAM — A student's major program is the field of primary interest and the one in which the greater portion of graduate work is taken. Programs are designed to prepare students to assume positions of informed and responsible authority in their fields and to contribute creatively to them. They promote not only specialization, but also breadth of scholarship, the ability to study and think independently, and familiarity with the principal techniques and important literature in the field. The research undertaken by the candidate should deal with a problem which represents a significant contribution to knowledge.

SPECIAL INTERDISCIPLINARY MAJORS — In addition to the graduate major programs listed in this bulletin on pages 83-84, special interdisciplinary majors involving two or more departments within a single college, or intercollege majors involving two or more colleges, may be arranged with the approval of the dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental or intercollege committees.

In general, departments of the University are identified with specific major programs. Thus, aerospace engineering is a major program of study which is offered under the supervision of the Department of Aerospace Engineering. On the other hand, acoustics and genetics are major programs for which there are no corresponding departments. In such cases, a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one program. For instance, the Department of Material Sciences offers work in ceramic science, fuel science, metallurgy, and mineral processing.

Applicants for admission are encouraged to consult the person whose name is listed under the major program heading in the Programs and Courses section.

ADVANCED DEGREES OFFERED

The degrees of Doctor of Philosophy and Doctor of Education are conferred by the University. Both require high attainment and productive scholarship, but the Ph.D. places a strong emphasis on research, whereas the D.Ed. emphasizes professional competence in some field of education.

The Master of Arts and the Master of Science degrees are academic in nature, the programs placing strong emphasis on basic knowledge and research. The professional master's degrees conferred are the Master of Administration, Master of Agriculture, Master of Architecture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forest Resources, Master of Music, Master of Psychosocial Science, Master of Public Administration, and Master of Regional Planning.

Candidates for the M.Ad., M.P.A., M.Ps.Sc., or M.R.P. degrees may meet all the requirements for these degrees at the Capitol Campus of The Pennsylvania State University. Programs leading to the degree of Master of Engineering with a major in engineering science have been approved for Behrend College, the Radnor Center for Graduate Studies, and the Capitol Campus. The M.P.A. program also is available at the Radnor Center. Designation of location of program completion will be noted on the student's transcript.

CHANGE OF DEGREE OR PROGRAM

A graduate student who has been admitted for work in one major program but wishes to transfer to another should submit a request to the Office of Graduate Student Programs of the Graduate School. The student's credentials will be reviewed and the proposed new major department head or committee chairman consulted. If the change is approved but the student is inadequately prepared for the new major, the student may be required to make up certain undergraduate deficiencies.

A graduate student admitted for either an academic degree (M.A., M.S., or Ph.D.) or a professional degree (M.Ad., M.Agr., M.Arch., M.B.A., M.E.P.C., M.Ed., M.Eng., M.F.A., M.F.R., M.Mus., M.P.A., M.Ps.Sc., M.R.P., or D.Ed.) who wishes to change from one type of degree program to another must apply to the Office of Graduate Student Programs for the transfer. Similarly, a student who has earned a master's degree but wishes to earn a different type of doctoral degree must apply for a formal transfer. A student may be required to make up certain deficiencies if inadequately prepared for the new program.

GRADUATE CREDITS

It is important that the student understand that in the Graduate School the word "credit" has no meaning other than as a unit of time — time spent in residence and in off-campus graduate work. One credit stands for the equivalent of approximately one week of full-time graduate work, and 10 credits for a term's work.

Typically, a candidate for an advanced degree is required to earn a certain minimum number of credits at The Pennsylvania State University. Consequently, there is a limit to the number of credits which may be earned at another approved institution or through continuing education to meet the minimum requirements of the degree. Moreover, the department or committee in charge of a major program may require a student to do more of the work at the University than specified by the limitations set by the Graduate Faculty. The normal credit load of a full-time graduate student is 8 to 10 credits per term, or the equivalent (see Academic Credit and Employment, page 67).

Graduate courses carry numbers from 500 to 599. Advanced undergraduate courses numbered between 400 and 499 may be used to meet some graduate degree requirements when taken by graduate students.

CONTINUING EDUCATION — A large number of courses carrying credit are given throughout the Commonwealth of Pennsylvania through continuing education. All 400-series courses so offered *may* be used to meet graduate degree requirements when taken by students who have been admitted to the Graduate School. The graduate adviser's signature is required on the official registration form, which the student submits at the designated place of registration for the course.

There is no limit to the number of credits which a student may earn in continuing education, but not more than 10 credits in 400-level courses so earned may be applied toward the minimum requirements for an advanced degree.

REGISTRATION

The responsibility for being properly registered rests with the student. The student is expected to register each term, for either course work or research toward the thesis, whether it be on or off campus. In the case of research, the number of credits shall be determined by the amount of time required for the investigation, one credit representing the equivalent of one week of full-time work. In the later stages of the program the situation will determine the requirements for the student's registration. (See below, **REGISTRATION NEAR THE COMPLETION OF A PROGRAM.**)

ADVISERS — To assist the student in planning a program, the head of the major department or program chairman will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of an adviser from the department head and to seek a conference before registration.

TIME OF REGISTRATION — Registration days are indicated in the calendar at the beginning of this catalog.

A student is expected to complete registration during the officially designated period and to attend

the first meeting of all classes. If this is impossible because of some emergency or unusual circumstance, the student may be granted permission by the instructor to miss a few class meetings, it being understood that work missed will be made up subsequently. Under these conditions permission may be granted through the Office of Graduate Student Programs for the student to register late. In general, a student who receives permission to register late will be required to reduce the course load in proportion to the length of the absence.

A student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge, regardless of when the student begins attending classes.

CONTINUITY OF REGISTRATION — A student who registers at University Park without interruption for each of the three terms in the September-to-June interval, for all four terms each year, or for summer terms only is considered to have maintained a normal continuity of registration.

Anyone who has interrupted such a normal sequence and now plans to register for work at the University Park Campus is required to apply to the Office of Graduate Student Programs, 211 Kern Graduate Building, at least one month before the time of registration, for permission to resume study.

The policy may be summarized for any specific term as follows:

Summer Term — Application required unless the student was registered at University Park for the preceding spring term or the preceding summer term.

Fall Term — Application required unless the student was registered at University Park for the preceding summer term or the preceding spring term.

Winter Term — Application required unless the student was registered at University Park for the preceding fall term.

Spring Term — Application required unless the student was registered at University Park for the preceding winter term.

PROCEDURE — For each registration the student, in consultation with the adviser, prepares a schedule of courses and research designed to fit individual needs. The credit load will be reviewed at the time of registration. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned for work done away from the campus. A student contemplating such work should inquire at the Office of Graduate Student Programs about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed before the close of central registration at University Park.

A student must register for courses audited as well as for those taken for credit.

REGISTRATION NEAR THE COMPLETION OF A PROGRAM — A candidate for the Ph.D. degree is required to register continuously (at least three terms of each four) from the time the comprehensive examination is passed and the three-term residence requirement is met until the thesis is accepted by the doctoral committee, regardless of whether work is being done on the thesis during this interval.

D.Ed. degree candidates and master's students may be required to register for a normal credit load because of their appointment status. If not, and if they have earned more than 90 (D.Ed.) or 30 (master's) credits and have met the requirements for their degrees except for the completion of the thesis, these students may register for as few as two credits per term. A student, other than the Ph.D. degree candidate, who has met the minimum requirements for a degree and is now completing research and thesis writing off campus is not required to register, even if visits are made to the campus several times each term to see an adviser, unless required to do so within the program.

A student, other than one following the Ph.D. requirement, is not required to register for the final term in order to graduate or in order to make minor revision to the thesis and/or to take a final examination for the degree, unless required to do so by the program.

VISITING AND AUDITING CLASSES — A graduate student registered for a given term who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during that term.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership, such as participating in discussion, doing practicum work, or tak-

ing examinations. Registration is not required for the privilege of visiting, and no record appears on the student's transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally enjoy the privileges of a class member. Registration procedures and fee payment are the same as for taking the course for credit. No credit is given, either on completion of the course or at a later time; however, the number of credits assigned to the course appears on the grade report and on the student's transcript. Thus, when a student receives an audit grade, the number of credits audited is shown. The symbol Au shall be used if attendance has been regular, the symbol W if attendance has been unsatisfactory.

A graduate assistant or fellow, who is required to register for a certain minimum number of credits, is not permitted to count audited course credits toward the minimum credits needed. The 1G and 2G language courses are an exception. The student may register for credit or audit beyond the required minimum but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for a course as auditors. However, visiting is not permitted in German 1G and 2G.

In the 1G and 2G courses offered by the language departments, no distinction is made between registering for credit and for audit in considering loads.

THESIS RESEARCH — In registering for thesis research a student uses the appropriate number (600, 610) preceded by the abbreviation designating the major field. The numbers 600 (on campus) and 610 (off campus) are available for credit in thesis research in all graduate major programs.

THESIS PREPARATION — The numbers 601 and 611 are available to Ph.D. degree candidates and are used for special noncredit registration for thesis preparation work. Such candidates must have passed the comprehensive examination and must have met the three-term residence requirement. A candidate registered for SUBJ. 601 is classified as a full-time student, while one registered for SUBJ. 611 is classified as a part-time student.

The numbers 600, 601, 610, and 611 may not always appear in the *Schedule of Classes* for each term.

COMMON COURSES — The following courses for which students may register have been set up for common use by major programs, with University Senate approval, to encourage innovation and provide flexibility in designing graduate programs:

590. **COLLOQUIUM (1-3)** Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.

596. **INDIVIDUAL STUDIES (1-6)** Creative projects, including nonthesis research, which are supervised on an individual basis and which fall outside the scope of formal courses. A specific title may be used in each instance and will be entered on the student's transcript. Multiple offerings may be accommodated by the use of suffixes a, b, etc.

597. **SPECIAL TOPICS (1-6)** Formal courses given on a topical or special interest subject which may be offered infrequently; several different topics may be taught in one year or term. A specific title may be used in each instance and will be entered on the student's transcript. Multiple offerings may be accommodated by the use of suffixes a, b, etc.

602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)** May be offered by any graduate program in a department which also offers undergraduate courses. A graduate program with no counterpart undergraduate program may offer SUBJ. 602 when cooperative arrangements are made with an administrative unit which does not offer graduate degrees but which uses graduate assistants in its teaching. SUBJ. 602 may be offered in any term and is subject to the following restrictions:

1. SUBJ. 602 shall not be counted in fulfilling any specific credit requirement for an advanced degree.
2. SUBJ. 602 shall be graded (A, B, C, D, F).
3. SUBJ. 602 shall not be used in calculating grade-point averages.
4. SUBJ. 602 shall be offered only in those graduate programs wishing to provide opportunity for supervised and graded teaching experience. Enrollment shall be restricted to students for whom the major program is prepared to provide such experience.

5. SUBJ. 602 may, but need not, be counted as a part of the normal credit load for graduate assistants.

ACADEMIC CREDIT AND EMPLOYMENT

To provide flexibility in arranging credit loads for graduate assistants and full-time University staff members, a procedure has been set up whereby the normal credit limits may be changed by permission of the person to whom the student or staff member is responsible for University employment or assistantship assignment. Maintenance of the established credit loads and responsibility for the consequences of a graduate student's change of course load rests with the student and adviser. The course load is a factor in determining whether a graduate student is classified as a full-time or part-time student; has met residence requirements; and is eligible to hold a fellowship, scholarship, assistantship, or departmental or program appointment. Students holding fellowships, traineeships, or other awards based on academic excellence are commonly required to carry 8 or more credits each term.

The University takes the position that the facilities of the Graduate School should be made available first to students who can profit from their graduate school experience to the maximum extent. More than doing what is required in courses or in research, the graduate experience is one of living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in discussions, both formal and informal, with faculty members and fellow students. It is an involvement and participation in student affairs, University and Graduate School governance, committee assignments, and personal contribution of effort to the welfare and betterment of the University graduate community. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of, one's specialty. Students who propose schedules of few credits not requiring serious effort, or those who wish to carry overloads of such proportion as to handicap them seriously in achieving maximum quality, find it difficult and often impossible to experience the satisfaction of a well-rounded scholarly attainment.

A graduate student should achieve a balance between academic credit load, employment, and appointment responsibilities which results in classification as a full-time graduate student with all the privileges and responsibilities intrinsic to this classification. The student's full-time classification is certified by the department head or program chairman and is sent to the Office of Graduate Student Programs.*

FULL-TIME ACADEMIC STATUS — In establishing credit loads, a student who in any term is registered for 8 or more credits *or* who holds a quarter-time assistantship and schedules 7 credits *or* who has a half-time assistantship and schedules 5-7 credits is considered to be engaged in full-time academic work for that term.

PART-TIME ACADEMIC STATUS — A student who in any term is registered for fewer than 8 credits and does not hold a half-time or quarter-time assistantship is considered to be engaged in part-time academic work for that term.

FULL-TIME EMPLOYMENT OFF CAMPUS — A candidate for the Ph.D. degree may not count the work of any term toward the residence requirement for this degree while engaged in full-time employment off campus.

BENEFITS AND PRIVILEGES — A student registered for 6 or more credits of course work *or* for noncredit SUBJ. 601 *or* who holds a half-time assistantship and is carrying at least 5 credits is entitled to the *nonacademic* student benefits and privileges of a full-time student.

STAFF EMPLOYEE CREDIT STATUS* — A full-time staff employee of the University may schedule 4 credits per term (up to 16 credits per academic year), either for credit or audit.

*Full-time University employees and three-quarter-time graduate assistants may meet Ph.D. degree residence requirements by registering for the full number of credits allowable (4 credits per term for full-time University employees, 4-5 credits for three-quarter-time assistants) and by obtaining certification from the department head as being principally engaged in activities relating to their academic programs.

No member of the faculty in one of the professorial ranks in the University may receive the master's degree or the doctoral degree from the University.

For University staff employees desiring to take graduate degree work, admission to the Graduate School is a first essential.

EMPLOYMENT — Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, whether on campus or off campus, must recognize the time demands of a work schedule in planning an academic program. A student holding a fellowship or scholarship may not accept employment of any kind for service beyond that specifically permitted by the appointment. Graduate assistants may accept concurrent employment outside the University only after obtaining permission from the head of the department providing the assistantship and from the person in charge of the assistant's graduate program. A graduate assistant may not hold a concurrent appointment with the University other than a Fellowship Supplement.

COURSE-NUMBERING SYSTEM — Courses in the series 1-399 are not listed in this catalog because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclass students with at least junior standing and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 75-82 under the specific requirements for the various master's degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.50, and other students who have been granted permission to enroll through the Office of Graduate Student Programs.

The numbers 600 (on campus) and 610 (off campus) are available for credit in thesis research in all graduate major programs. The numbers 601 and 611 do not denote courses but are used for noncredit special registration for thesis preparation by a Ph.D. candidate. Registration under these numbers will maintain status as a student during the interval which begins at the time the student passes the comprehensive examination and meets the three-term residence requirement and ends at the time the doctoral committee accepts the thesis. The student will register for 601 if engaged full time in the preparation of a thesis, or will register for 611 if engaged only part time in thesis preparation. Candidates for the Ph.D. degree do not receive grades for noncredit registrations (601 and 611).

SCHEDULE OF COURSES — A complete list of the courses which will be offered in any specific term is given in the *Schedule of Classes*, which is available at nominal cost from the Scheduling Office approximately four months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

The following grading system is in effect: Any one of five quality grades (A, B, C, D, F) may be given a graduate student for course work or for thesis research. The grade-point equivalents are 4, 3, 2, 1, 0, respectively.

At the 400, 500, and 600 levels, grades of A, B, and C denote graduate credit, whereas D and F are failing grades for graduate students, D being the normal failing grade. A grade of F indicates doubt in the judgment of the instructor of the student's potential for further graduate study.

A minimum grade-point average of 3.00 for work done at the University is required for graduation.

In addition to the quality grades listed above, two symbols, Def. (deferred) and R, may appear on a student's transcript. If work is incomplete at the end of a term for a reason beyond the student's control, or if very little work remains to be done, the instructor may report Def. in place of a grade, which will appear temporarily on the student's record. The deferral must be removed within six weeks of the beginning of the succeeding term, unless a special extension is granted by the associate dean of the Office of Graduate Student Programs. If the work is completed within the specified period of deferral, and the instructor does not report a passing grade, the Graduate Recorder automatically records a failing grade after duly notifying the department head or program chairman to that effect. No student may be ap-

proved for a degree while a grade deferral for a required course remains on the record. Deferred grade cards may be obtained from the Graduate Recorder, 112 Shields Building.

In the case of thesis work, either in progress or completed, and certain courses approved by the University Senate, the instructor may report the symbol R in place of a grade. This symbol indicates that the student has devoted an adequate amount of time to the work scheduled but gives no indication of its quality. When reported for thesis work, this symbol will not influence the grade-point average and remains on the student's transcript permanently if not converted to a quality grade (A, B, C, D, or F) within one term of its recording. Quality grades reported for a given term for thesis work will be included in the cumulative grade-point average. Quality grades reported for research will not apply to R's given for earlier registrations and will not denote the quality of an entire series of R's. It is expected that an R grade for a course will be changed to a quality grade when the work for that course has been completed. Ordinarily, a quality grade will be reported no later than the end of the following term.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in a degree program will be dropped from the University. A cumulative grade-point average below 3.00 for any term or terms may be considered as evidence of failure to maintain satisfactory scholarship. Action may be initiated by the department or committee in charge of the graduate major or by the chairman of the student's doctoral committee.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of intention to graduate (by filing a diploma card) and to pay the thesis fee at the beginning of the term in which an advanced degree is expected to be received. If the student does not graduate, the diploma card must be reactivated during the actual term of graduation. Deadlines are given in the calendar found at the beginning of this bulletin.

A preliminary graduation list is prepared by the Graduate Recorder soon after the deadline for each term. Transcripts are prepared and checked in the offices of the Graduate School and the Recorder. The records of candidates who appear to have met requirements are forwarded to major and minor department heads or program chairmen for review and recommendation. The final list of approved candidates appears in the commencement program.

Only those transfer credits which have been accepted by the Graduate School and entered upon the student's transcript by the Recorder before the graduate list deadline will be considered in evaluating a student for graduation at the end of that particular term.

Attendance at commencement exercises is expected, but forms for permission to receive the degree in absentia are available in the Office of Graduate Student Programs in 211 Kern Graduate Building and in the Office of Graduate Records in 112 Shields Building. The form must be completed and filed with the Graduate Recorder by the date specified in the Graduate Calendar.

All degrees conferred are tentative until final grade reports have been received and all requirements fulfilled, even though the student's name may have appeared in the commencement program. A student's transcript or diploma, or both, may be withheld until any outstanding financial obligations to the University have been paid.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred by the University. Recognized as different in purpose, the two programs consequently have different requirements in certain respects.

ADMISSION

A student who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major program in which the doctorate is offered may begin working toward a

doctoral degree. However, the student has no official status as a doctoral student and no assurance of acceptance as a doctoral candidate until the candidacy examination has been passed. This examination is administered by the major department or graduate program and is given early in the student's program.

It is the policy of the Graduate School not to permit applicants to work for a second doctoral degree. The President, on recommendation of the dean of the Graduate School, will welcome, as guests, holders of earned doctoral degrees who may be visiting the University Park Campus for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the dean of the Graduate School.

GENERAL REQUIREMENTS

No specified number of courses completed or credits earned will assure attainment of the doctorate. The general requirements are based upon a period of residence, the writing of a satisfactory thesis, and the passing of a comprehensive and a final oral examination. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate in some major programs. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly, the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed. degree.

GRADE-POINT AVERAGE

A minimum grade-point average of 3.00 for work done at the University is required for admission to the comprehensive examination and for graduation.

TIME LIMITATION

A student is required to complete the program within seven years from the date of acceptance as a candidate.

OFF-CAMPUS AND TRANSFER CREDITS

Subject to the approval of the adviser and the head of the major department or program chairman, a student may register for research to be done away from the University Park Campus.

A maximum of 30 credits beyond the baccalaureate at an approved school not granting the doctorate in the student's major program may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. A maximum of two full academic years of work (60 credits) beyond the baccalaureate at a graduate school which grants the doctorate in the candidate's major program may be accepted here to apply toward doctoral degree requirements. Advanced standing is awarded for only one master's degree. Academic work to be so transferred must meet the following criteria: (1) It must have been completed within five years prior to the date of admission to the Graduate School of The Pennsylvania State University; (2) it must appear on a graduate transcript; (3) it must be of at least B quality; and (4) it must be deemed applicable to the student's program by the current academic adviser, approved in writing, and submitted to the Graduate School director of admissions. Credit earned externally in postbaccalaureate professional degree programs (law, medicine, etc.) is not transferable.

The following caveat should be noted. Pass-fail grades are not transferable to an advanced degree program unless the "pass" can be substantiated by the former institution as having at least B quality.

A completed master's degree may be transferred to a doctoral program with no intervening time limitation.

ADVISERS AND DOCTORAL COMMITTEES

Following admittance to a degree program, the student should confer with the head of that major department or program concerning procedures and the appointment of an adviser. Arrangement and ap-

proval of the details of the student's term-by-term schedule is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major program for this specific duty.

General guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of four or more members of the Graduate Faculty. One member shall be from outside the candidate's major program. (For the D.Ed. doctoral committee, this committee member must be a faculty member in the candidate's minor field or general studies area — *See MAJOR PROGRAM AND MINOR FIELD under D.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS.*) This committee is appointed through the Office of Graduate Student Programs, upon recommendation of the head of the major program, after the student is admitted to candidacy. At the discretion of the associate dean, other members may be added to the committee. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. The chairman, with the following exception, must hold senior membership in the Graduate Faculty. An associate member may supervise the research for a doctoral candidate, and, with the approval of the associate dean of the Graduate School, may serve as chairman of a doctoral committee.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after the student's admission to candidacy. It will prepare, give, and evaluate the candidate's examinations, and supervise and approve the thesis. A favorable vote of at least two-thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether another examination may be taken.

The committee will also notify the associate dean when the candidate is ready to have the comprehensive and the final oral examinations scheduled and will report the results of these examinations to the Office of Graduate Student Programs.

COMMUNICATION AND FOREIGN LANGUAGE COMPETENCE

A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School or must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must meet any communication and foreign language requirements which have been established within the major program. The candidate should ascertain specific language requirements by contacting the professor in charge of the program, whose name appears with the program description under **GRADUATE MAJOR PROGRAMS AND COURSES**.

If a candidate is to be examined for knowledge of a foreign language other than French or Spanish, the intention to take the examination must be reported to the secretary of the language department by the end of the first week of classes for the term during which the examination is to be taken. This date is one week prior to the examination date. This written examination will be administered on dates announced for each term in the Graduate Calendar at the beginning of this catalog.

The Pennsylvania State University has been named by Educational Testing Service as a testing center for the administration of the written tests for students to be examined in French or Spanish. Students wishing to make application to take these tests should, at their earliest convenience, check with the Office of Examination Services, 207 Mitchell Building, University Park, PA 16802. A test fee of \$12 is payable at the time of application. Times and places of tests will be given when the test application is filed.

Candidates for the Doctor of Education degree may be required to demonstrate competence in foreign languages.

CANDIDACY EXAMINATION

The candidacy examination is administered by the Graduate Faculty in the graduate major program and should be taken early in the student's program. The nature of the examination varies with the program and may be the master's examination if so allowed. The decision to admit or not to admit a student to candidacy must be made by the Graduate Faculty or a designated committee of Graduate Faculty. For the Ph.D. student the examination may be given after at least 12 credits have been earned in graduate

courses beyond the baccalaureate. The examination must be taken within three terms after having earned 24 credits.

For the D.Ed. student, the examination should be given when the student has earned a total of approximately 30 credits, including the master's program and work done elsewhere. A student transferring from another graduate school with 30 or more transfer credits must take the candidacy examination prior to earning more than 10 credits here.

COMPREHENSIVE EXAMINATION

When a candidate for the Ph.D. or D.Ed. degree has substantially completed the course work, a comprehensive examination covering the major program and minor field of study is required.

A candidate for the Ph.D. must have satisfied the communication and foreign language requirement before taking the examination.

All candidates are required to have a minimum grade-point average of 3.00 for work done at the University at the time the comprehensive examination is given.

The examination is officially scheduled and announced by the associate dean for graduate student programs upon recommendation of the doctoral committee. It is given and evaluated by the doctoral committee and may be *either written or oral, or both*. A favorable vote of at least two-thirds of the members of the committee is required for passing. In case of failure it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The results are reported to the Office of Graduate Student Programs and will be entered on the candidate's official record.

When a period of more than five years has elapsed between the passing of the comprehensive examination and the completion of the program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

FINAL ORAL EXAMINATION

The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the associate dean for graduate student programs, on the recommendation of the doctoral committee, to take a final examination. Normally the final oral examination may not be scheduled until at least three months have elapsed after the comprehensive examination was passed, although the associate dean may grant a waiver in the case of an outstanding student. The deadline for holding the examination is seven weeks before commencement. It is the responsibility of the doctoral candidate to provide a copy of the thesis to each member of the doctoral committee at least one week before the date of the scheduled examination.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the candidate's whole program of study without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two-thirds of the members of the committee is required for passing. The results of the examination are reported to the Office of Graduate Student Programs and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether another examination may be taken.

Ph.D. — ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation; (2) the preparation of a thesis involving independent research; and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

RESIDENCE REQUIREMENTS

There is no required minimum of credits or terms of study, but over some twelve-month period during the interval between admission to candidacy and completion of the Ph. D. program the candidate must spend at least three terms (which may include the term in which the candidacy examination is taken) as a registered full-time student engaged in academic work on the University Park Campus or at The Milton S. Hershey Medical Center. Full-time University employees must be certified by the department as devoting half time or more to graduate studies and/or thesis research to meet the degree requirements (see Academic Credit and Employment, page 67).

CONTINUOUS REGISTRATION

After a student has passed the comprehensive examination *and* met the three-term residence requirement, no further registration for credit will be required by the Graduate School. However, status as a student must be maintained by registering continuously (at least three terms of each four, beginning with the first term after both of the requirements mentioned above have been met) until the thesis is accepted by the doctoral committee. This registration may be for (1) noncredit 601 or 611 only, with payment of the special thesis preparation fee; (2) noncredit 601 or 611 with payment of the special thesis preparation fee plus course registration at the regular per credit fee; or (3) full-time course credits with payment of the regular tuition fee. Grades are not given for noncredit 601 or 611. Failure to maintain registration will result in termination of student status.

MINOR FIELD

A Ph. D. candidate is not required by the Graduate Faculty to have a minor field of study. However, a department or a committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of the doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the master's degree, of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major program and the minor field.

THESIS

The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal an ability on the part of the candidate to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis must be submitted to the Office of Theses and Publications not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin*, which gives details concerning format, paper, typing, and other requirements, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building. Following editorial review of the thesis by this office, it is expected that the student will submit a copy of the thesis, incorporating format corrections, to the office of the department or program head.

D.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge and concurrence by the dean of the

College of Education, may also be offered in any other field appropriate to the preparation of professional educators which has been approved for the doctorate.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles to practitioner problems in a variety of education endeavors; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successful performance on major and minor examinations, showing a satisfactory grasp of the field of specialization and its relation to allied education areas.

RESIDENCE REQUIREMENTS

A minimum of nine terms of full-time graduate study and research (10 credits per term), or their equivalent in credits (90 credits), of which at least 30 credits must be earned in residence, is required for the D.Ed. degree. The D.Ed. candidate may meet the requirements by attending summer terms unless the major department requires a period of registration in other terms or in consecutive terms at University Park. A candidate may register for a maximum of 30 credits of research in absentia, but none of these may count toward the minimum of 30 credits which must be earned at the University Park Campus. It is expected that students will register for a minimum of 15 credits of thesis research. The maximum credit load permitted a student who is employed full time is 4 credits per term.

MAJOR PROGRAM AND MINOR FIELD

The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major program of study.

A candidate choosing a major outside the field of education (such as history) shall have a minor consisting of no fewer than 15 credits in education, including those applied toward the master's degree, as recommended to the dean of the Graduate School early in the major program with the approval of a faculty adviser designated by the dean of the College of Education.

A candidate choosing a major in one of the major programs in education must also choose either a minor or a group of general studies with the approval of the major program chairman. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside those of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields outside those of education considered by the major program committee to have significance and value for the candidate.

COMPREHENSIVE EXAMINATION

In addition to demonstrating a high level of competence in the subject matter in the major program and minor field, each candidate must show, by a comprehensive examination, an understanding of current theories of education and the ability to apply the techniques and findings of educational research so far as they bear upon the teaching of the subject matter. The candidate must also be able to understand and contribute to the technical and professional literature in the field, and to criticize learned procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include competence in the use of statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates are required to have a minimum grade-point average of 3.00 for work done at the University at the time the comprehensive examination is given.

THESIS

Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought, as well as ability and originality in the application of educational principles or in the development of new generalizations under scientific controls. A thesis may be based upon a product or project of a professional nature, provided scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in

order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis must be submitted to the Office of Theses and Publications not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin*, which gives details concerning format, paper, typing, and other requirements, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building. Following editorial review of the thesis by this office, it is expected that the student will submit a copy of the thesis, incorporating format corrections, to the office of the department or program head.

MASTER'S DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees, academic and professional. Of the fifteen master's degrees conferred, the Master of Arts and Master of Science are academic in nature. The professional degrees conferred are Master of Administration, Master of Agriculture, Master of Architecture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forest Resources, Master of Music, Master of Psychosocial Science, Master of Public Administration, and Master of Regional Planning.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements as specified below under Additional Specific Requirements.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts the continuity of registration faces the possibility of not being granted permission to return.

GRADE-POINT AVERAGE

A minimum grade-point average of 3.00 for work done at the University is required for graduation.

TIME LIMITATION

All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

ADMISSION

In addition to the general University requirements for admission set forth at the beginning of this catalog, adequate undergraduate preparation is required in the program in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of program and can be ascertained from the descriptive statement appearing under the major program heading in the latter portion of this catalog. An applicant who meets the necessary grade-point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and be allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the necessary period of residence. An applicant for admission to the M.Ed. program in most major programs is required to have had at least 18 credits in education and related psychology, and in certain major programs may be required to have had practice teaching.

After admission to a degree program, a student should confer with the head of the major department or program concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major

department or program in which the student is specializing. The adviser or the committee assists the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments or programs in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department or program.

TRANSFER CREDIT

Subject to the limitations given, a maximum of 10 credits of high-quality graduate work done at another institution may be applied toward the requirements for the master's degree. However, credits earned to complete a previous master's degree may not be applied to a second master's degree program at The Pennsylvania State University.

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program. Approval to apply any transferred credits toward a degree program must be granted by the student's academic adviser, and the adviser must notify the Graduate School director of admissions, in writing, when such approval is granted. Transferred academic work must have been completed within five years prior to the date of admission to the Graduate School of The Pennsylvania State University, must be of at least B quality, and must appear on a graduate transcript. Credit earned externally in postbaccalaureate professional degree programs (law, medicine, etc.) is not transferable.

Pass-fail grades are not transferable to an advanced degree program unless the "Pass" can be substantiated by the former institution as having at least B quality.

Forms for transfer of credit may be obtained from the Office of Graduate Admissions, 201 Kern Graduate Building.

EXAMINATIONS

A candidate may be required to pass in a satisfactory manner written or oral examinations designated by the program head. A candidate should consult the major department or program for special requirements.

Examinations to establish credit for work done in absentia or without formal class work may be used to remove undergraduate deficiencies, but *not* to earn credits toward an advanced degree. Arrangements are made by the student directly with the major department head or program chairman.

Graduate Record Examinations are designed to test information and abilities in basic fields of knowledge. Provisions are made on the campus for administering these examinations at scheduled times and upon request of students or department program chairmen. Informational materials may be obtained at the Graduate School Information Center on the first floor of Kern Graduate Building.

M.A. and M.S. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred. Programs for both degrees are strongly oriented toward research.

A minimum of 30 graduate credits is required, of which at least 20 must be earned at an established graduate campus of the University. Some graduate programs require additional credits; the exact number can be determined by consulting the specific program description in the subsequent section GRADUATE MAJOR PROGRAMS AND COURSES. A minor is not required of all candidates for the M.A. or M.S. degree. A department or committee in charge of a major program may require a candidate to offer work in a minor field, or the minor may be elected with the permission of the student's committee.

A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major program and minor field.

The major department or the committee in charge of the major program is the judge as to the suitability of a field for the minor and of its relevance to the major. The minor field department has the responsibility of accepting or rejecting students, advising on courses to be taken by the candidate in the field, examining the candidate in the area of studies undertaken in the field, and certifying that the minor requirements have been met.

At least 18 credits in the 500 and 600 series, combined, must be included in the program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed in the major program. A thesis is required of many candidates for these degrees. Details are given in the introductory paragraphs under the major program headings in the latter part of this catalog. If a student is required to write a thesis, at least 6 credits in thesis research (600 or 610) must be included in the program. If no thesis is required, at least 18 credits must be in 500-level courses.

A thesis is prepared under the direction of the department or program in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off campus. To do so, satisfactory arrangements must be made in advance with the adviser and the head of the major department or program.

Those candidates who are not required to write a thesis must present a suitable essay or paper. Its nature and extent shall be determined by the major program. The department head or program chairman shall report to the Office of Graduate Student Programs the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The program head may require one or more copies of the essay for the program's library or other files.

Some programs in the field of education offer the M.S. degree but prefer to admit students into the M.Ed. degree program. Other programs which emphasize research prefer to admit only students interested in pursuing the Ph.D. degree.

Requirements for the M.A. degree at the Capitol Campus differ somewhat from the above and are outlined under the major programs in American Studies and Humanities. These programs are available only at the Capitol Campus.

A *Thesis Information Bulletin*, which gives details concerning format, paper, typing, and other requirements, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building. Following editorial review of the thesis by this office, it is expected that the student will submit a copy of the thesis, incorporating format corrections, to the office of the department or program head.

M.Adm. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Administration degree program is offered only at the Capitol Campus. It is intended to meet the professional needs of practicing and potential administrators in the fields of business and engineering. Two options are offered: (1) the business administration option is intended for students who desire to pursue an administrative career in business, industry, or institutions; and (2) the engineering administration option prepares individuals for management positions in engineering, scientific, and technical organizations. Each student is required to complete a professional paper of the quality, if not the theoretical depth, of a thesis.

A description of the Administration program appears subsequently in this catalog. Further information can be obtained from the Capitol Campus.

M.Agr. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Agriculture is a professional degree. Programs leading to this degree provide opportunities for students to increase their knowledge and competences in the various phases of agriculture. A

student, according to individual objectives, may obtain intensive training encompassing a wide spectrum of subject matter area or intensive training in a specialized area. The emphasis of the program is to enable students to develop skill as professional practitioners in the communication of technical knowledge and its application to the solution of current and future technical, economic, and social problems of individuals and groups.

The head of the department or program chairman shall appoint a three-member committee to guide and monitor the candidate's professional development. Members of this committee must represent at least two departments. The chairman of the appointed committee shall serve as the candidate's adviser. The candidate will inform the committee of personal aspirations and background early in the program. The committee will suggest to the student how best to achieve these goals and the standard of professional competence required for the Master of Agriculture degree.

A minimum of 30 graduate credits is required, of which 20 credits must be earned in residence at the University Park Campus. A maximum of 10 credits may be earned in special problem-type courses.

The candidate must present an acceptable paper on a selected professional problem or a report of internship training. Up to 3 graduate credits will be given for an acceptable paper. The candidate may be required to provide one or more copies of the paper for the University.

The candidate's committee shall report, through the department head or program chairman, to the Office of Graduate Student Programs the title of the paper and whether the paper and the candidate's academic performance were considered satisfactory.

M.Arch. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Architecture is a professional degree and is planned to provide the depth and breadth of knowledge needed to enter the architectural profession and become a licensed professional architect following the required period of internship. Admission requirements include the equivalent of 39 credits in design-research work and a statement of purpose concerning the professional aims of the candidate. The program is available to candidates holding a B.A. or B.S. degree with a major in architecture or environmental design, or holding other nonprofessional degrees in architecture.

A minimum of 60 graduate credits at 400/500 level is required, 36 of which must at the 500 level. A minimum of 30 credits must be taken at the University Park Campus. A thesis is optional. If a thesis is written, 6 credits of Arch. 600 must be completed. Professional areas of study include building design and architectural programming.

M.B.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The purpose of the Master of Business Administration degree program is to develop professional managerial knowledge and skills as these are applied to the decisions in complex organizations. Teaching focuses upon the techniques, the concepts, and the skills important to modern administrators.

A minimum of 48 graduate credits is required, all at the 500 level. Thirty-six credits must be in specified core courses. Also required are 12 credits in major field courses and electives (including a professional paper). Work for this degree may be started in the fall term only. Applications must include the results of the Graduate Management Admission Test.

M.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in education. They should be distinguished carefully from the research-oriented programs which lead to the academic degrees of Master of Arts or Master of Science. In most major programs the requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned at an established graduate campus of the University; at least 24 must be in course work. This degree is also offered at the Capitol Campus and the Radnor Center for Graduate Studies.

MAJOR PROGRAMS IN THE FIELDS OF EDUCATION

A student may major in one of the approved programs in education, such as curriculum and instruction, educational psychology, or home economics education, and proceed under the guidance of a graduate faculty member in the appropriate major in education. At least 12 of the required credits in course work must be taken at the 500 level.

A program of this type requires at least 6 credits to be earned outside the programs in education, or the 6-credit requirement may be met with course work in the specific fields of educational psychology or cultural foundations of education.

MAJOR PROGRAMS OUTSIDE THE FIELDS OF EDUCATION

A student who is preparing to teach in a specific subject-matter field, such as economics, mathematics, or German, may choose such a program as a major and take a majority of work in it under the guidance of the department offering that major. A student wishing to study in a broader area may choose a major such as human development and family studies, earth sciences, or extension education and take at least 24 credits in the area under the guidance of the committee in charge of the major.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits may be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology.

THESIS OR PAPER

Six credits may be granted for an approved thesis. A candidate who does not elect to write a thesis is required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of this piece of writing, whether it be required in connection with a course or independent of course work, and when it is to be undertaken shall be determined by the major program. The program chairman shall report to the Office of Graduate Student Programs the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the program chairman to require one or more copies of the essay for the program's library or other files.

M.Eng. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Engineering provide training for advanced professional competence in the several fields of engineering. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required, of which 20 must be earned at an established graduate campus of the University. At least 12 credits must be earned in graduate courses (500 series).

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

Work for this degree is not required to be done specifically on the University Park Campus. A complete program of study can be pursued at the Capitol Campus, at Behrend College, or at the Radnor Center for Graduate Studies of The Pennsylvania State University.

M.E.P.C. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Environmental Pollution Control is an intercollege professional degree designed for students who are interested in pursuing a career in the field of environmental pollution control. Special requirements include 9 credits of core courses covering air and water pollution control and solid waste management and participation in the environmental pollution control seminar program. A minimum of 30 graduate credits is required, of which at least 9 must be at the 500 level and 20 must be taken at the University Park Campus. A thesis is optional. If a thesis is written, at least 6 credits of thesis research (600 or 610) must be taken. Those who select the nonthesis option must submit a paper.

M.F.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Fine Arts provide training for increased professional competence in the several specialized areas of the arts. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts with a major in art or theatre arts.

A minimum of 48 credits is required, of which at least 38 must be earned at the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate in a particular field.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect of the program; the project and monograph shall represent a minimum of 6 credits on the 600 level.

M.F.R. — ADDITIONAL SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Forest Resources provides training for increased professional competence in the several specialized areas of forest resource management and forest products. It should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Science with a major in forest resources.

A minimum of 30 graduate credits is required, of which at least 20 must be earned at an established graduate campus of the University. At least 12 credits must be in courses at the 500 level, excluding F.P. 596, For. 596, and Wildl. 596.

A candidate for the degree of Master of Forest Resources may elect a minor with the permission of the committee. A minor consists of no fewer than 6 credits of integrated work in one field related to, but different from, that of the major. A minor program must meet the approval of the department or committee responsible for the minor field.

Each candidate is required to submit an acceptable paper which demonstrates an ability to apply to the professional field the knowledge gained during his or her program. Six to 9 graduate credits will be given for this paper, which will be evaluated by the student's committee, defended in an oral exam, and reviewed by a member of the Graduate Faculty not on the student's committee.

M.Mus. — ADDITIONAL SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Music provides training for increased professional competence in music. It should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Arts with a major in music history.

A minimum of 36 credits is required, of which at least 30 must be earned at the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect of the program; the project and monograph shall represent a minimum of 6 credits on the 600 level.

M.P.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration in local, state, and national governmental jurisdictions or in international, private, or voluntary agencies. The M.P.A. degree is offered at the University Park Campus, the Capitol Campus, and the Radnor Center for Graduate Studies.

The M.P.A. degree offered at University Park and Radnor requires a minimum of 30 graduate credits, of which 20 must be earned at the University Park or Radnor campuses. The greater portion of the courses must be at the 500 level. An M.P.A. essay or paper will also be required but will carry no graduate credit. A comprehensive final examination will be given to all candidates.

The M.P.A. degree offered at the Capitol Campus at Middletown requires a minimum of 45 graduate credits including a 9-credit field study (internship) experience and a professional master's project. The 9-credit field study requirement may be waived for students who have at least three years of full-time professional experience in relevant administrative or staff work. There is no comprehensive final examination, but an oral defense of the master's project report is required.

The program leading to the Master of Public Administration degree should be distinguished from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science, in which the candidate may specialize in public administration.

M.Ps.Sc. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Psychosocial Science degree, community psychology option, is a non-traditional program with an emphasis on practicum experience. The program is concerned with equipping students with some of the skills necessary to cope effectively with the multifaceted problems facing communities. Students should be able to recognize problems, to outline and implement possible solutions to these problems, and to evaluate the effectiveness of the solutions.

Forty-five graduate credits are required, 24 at the 500 level. A major portion of this degree is field work under the supervision of a faculty member. A paper is a necessary part of the practicum experience. An oral defense of the paper is required.

M.R.P. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Regional Planning is a professional degree for students interested in a multidisciplinary approach to the problems of regional and community development and resource management. The program provides the student with a solid background in planning theory and techniques, emphasizing planning within a multijurisdictional context in both urban and rural areas. The program provides flexibility for students to develop an area of specialization or to pursue a concurrent degree in a discipline related to planning.

For the M.R.P. degree at the University Park Campus, a minimum of 54 approved graduate credits is required, of which 36 must be earned at a graduate campus of the University. Six graduate credits will be earned in preparing (1) a thesis or (2) a professional paper comparable in quality and scope to a graduate thesis.

The M.R.P. degree at the Capitol Campus at Middletown requires a minimum of 45 graduate credits, 35 of which are required in planning courses, at least 6 of which will be earned in preparing (1) a problem-oriented thesis, or (2) an individual project report comparable in quality and scope to a graduate thesis, or (3) a project written in a terminal integrative course in regional planning.

GRADUATE MAJOR PROGRAMS OF STUDY

The following degrees are the ones normally conferred in each of the designated major programs. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head or program chairman and the dean of the Graduate School. For example, the M.Ed. has been authorized for all of the programs below in which a master's degree is conferred provided the program is appropriate to the preparation of teachers.

*Acoustics — Ph.D., M.S., M.Eng.
 Administration (Capitol) — M.Adm.
 Aerospace Engineering — Ph.D., M.S.
 Agricultural Economics — Ph.D., M.S., M.Agr.
 Agricultural Education — Ph.D., D.Ed., M.S., M.Ed.
 Agricultural Engineering — Ph.D., M.S.
 Agronomy — Ph.D., M.S., M.Agr.
 American Studies (Capitol) — M.A.
 Anatomy (Hershey) — Ph.D., M.S.
 Animal Industry — Ph.D., M.S., M.Agr.
 Animal Nutrition — Ph.D., M.S.
 Anthropology — Ph.D., M.A.
 Architectural Engineering — M.S.
 Architecture — M.S., M.Arch.
 Art — M.A., M.F.A.
 Art Education — Ph.D., D.Ed., M.S., M.Ed.
 Art History — Ph.D., M.A.
 Astronomy — Ph.D., M.S.
 Biochemistry — Ph.D., M.S.
 *Bioengineering — Ph.D., M.S.
 Biochemical Chemistry (Hershey) — Ph.D., M.S.
 Biology — Ph.D., M.S.
 Biophysics — Ph.D., M.S.
 Botany — Ph.D., M.S.
 Business Administration — Ph.D., M.S., M.B.A.
 Ceramic Science — Ph.D., M.S.
 Chemical Engineering — Ph.D., M.S.
 Chemistry — Ph.D., M.S.
 Civil Engineering — Ph.D., M.S., M.Eng.
 Classics — M.A.
 Communication Disorders — Ph.D., D.Ed., M.S., M.Ed.
 Community Systems Planning and Development — Ph.D., M.S.
 Comparative Literature — Ph.D., M.A.
 Computer Science — Ph.D., M.S.

Counselor Education — Ph.D., D.Ed., M.S., M.Ed.
 Curriculum and Instruction — Ph.D., D.Ed., M.S., M.Ed.
 Dairy Science — Ph.D., M.S.
 Developmental and Remedial Reading — M.Ed.
 Earth Sciences — D.Ed., M.Ed.
 *Ecology — Ph.D., M.S.
 Economics — Ph.D., M.A.
 Educational Administration — Ph.D., D.Ed., M.S., M.Ed.
 Educational Psychology — Ph.D., M.S.
 Electrical Engineering — Ph.D., M.S.
 Engineering Mechanics — Ph.D., M.S., M.Eng.
 Engineering Science — M.S.
 Engineering Science (Behrend, Radnor, Capitol) — M.Eng.
 English — Ph.D., D.Ed., M.A., M.Ed.
 Entomology — Ph.D., M.S., M.Agr.
 Environmental Engineering — M.S., M.Egg., Ph.D.
 *Environmental Pollution Control — M.S., M.Eng., M.E.P.C.
 Extension Education — M.Agr., M.Ed.
 Food Science — Ph.D., M.S.
 Forest Resources — Ph.D., M.S., M.Agr., M.F.R.
 French — Ph.D., D.Ed., M.A.
 Fuel Science — Ph.D., M.S.
 *Genetics (U.P., Hershey) — Ph.D., M.S.
 **Geochemistry and Mineralogy — Ph.D., M.S.
 Geography — Ph.D., M.S.
 **Geology — Ph.D., M.S.
 **Geophysics — Ph.D., M.S.
 German — Ph.D., M.A., M.Ed.
 Higher Education — D.Ed., M.Ed.
 History — Ph.D., D.Ed., M.A., M.Ed.
 Home Economics Education — Ph.D., D.Ed., M.S., M.Ed.

*Intercollege Graduate Program

**See Geosciences

- Horticulture — Ph.D., M.S., M.Agr.
 Human Development and Family Studies —
 Ph.D., D.Ed., M.S., M.Ed.
 Humanities (Capitol) — M.A.
 Industrial Engineering — Ph.D., M.S.,
 M.Eng. (Radnor, M.Eng.)
 Journalism — M.A.
 Laboratory Animal Medicine (Hershey) —
 M.S.
 Linguistics — Ph.D., M.A.
 Man-Environment Relations — Ph.D.,
 D.Ed., M.S., M.Ed.
 Mathematics — Ph.D., D.Ed., M.A.,
 M.Ed.
 Mathematics (Radnor) — M.Ed.
 Mechanical Engineering — Ph.D., M.S.,
 M.Eng.
 Metallurgy — Ph.D., M.S.
 Meteorology — Ph.D., M.S.
 Microbiology — Ph.D., M.S.
 Microbiology (Hershey) — Ph.D., M.S.
 Mineral Economics — Ph.D., M.S.
 Mineral Engineering Management —
 M.Eng.
 Mineral Processing — Ph.D., M.S.
 Mining Engineering — Ph.D., M.S.,
 M.Eng.
 Music — M.A., M.Mus.
 Music Education — D.Ed., M.Ed.
 Nuclear Engineering — Ph.D., M.S.,
 M.Eng.
 Nursing — M.S.
 Nutrition — Ph.D., D.Ed., M.S., M.Ed.
 Nutrition in Public Health — M.S.
 †Operations Research — Ph.D., M.S.
 Petroleum and Natural Gas Engineering —
 Ph.D., M.S.
 Pharmacology (Hershey) — Ph.D., M.S.
 Philosophy — Ph.D., M.A.
 Physical Education — Ph.D., D.Ed.,
 M.S., M.Ed.
- Physics — Ph.D., D.Ed., M.S., M.Ed.
 *Physiology (U.P., Hershey) — Ph.D.,
 M.S.
 Plant Pathology — Ph.D., M.S., M.Agr.
 Political Science — Ph.D., M.A.
 Polymer Science — Ph.D., M.S.
 Poultry Science — M.S.
 Psychology — Ph.D., M.S.
 Psychosocial Science (Capitol) —
 M.Ps.Sc.
 Public Administration — M.P.A.
 Public Administration (Capitol) —
 M.P.A.
 Recreation and Parks — M.S., M.Ed.
 *Regional Planning — M.R.P.
 Religious Studies — Ph.D., M.A.
 Rural Sociology — Ph.D., M.S., M.Agr.
 *School Psychology — D.Ed., M.S.,
 M.Ed.
 Slavic Languages and Literatures — M.A.
 Sociology — Ph.D., M.A.
 *Solid State Science — Ph.D., M.S.
 Spanish — Ph.D., D.Ed., M.A., M.Ed.
 Speech Communication — Ph.D., M.A.
 Special Education — Ph.D., D.Ed., M.S.,
 M.Ed.
 Statistics — Ph.D., M.S., M.A.
 Teaching and Curriculum (Capitol) —
 M.Ed.
 Theatre Arts — M.A., M.F.A.
 Urban and Regional Planning (Capitol) —
 M.R.P.
 Veterinary Science — Ph.D., M.S.
 *Vocational Education — Ph.D., D.Ed.
 Vocational Industrial Education —
 Ph.D., D.Ed., M.S., M.Ed.
 Wildlife Management — M.S.
 Zoology — Ph.D., M.S.

*Intercollege Graduate Program

†Dual-title Program Option

GRADUATE MAJOR PROGRAMS AND COURSES*

ACOUSTICS (ACS)

JIRI TICHY, *Chairman of the Committee on Acoustics*
Applied Research Laboratory, Applied Science Building
814-865-6364

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Ackerman, Baker, Brown, Brubaker, Fenlon, Hayek, Johnson, Lauchle, Martin, Michael, Neubert, Pigott, Reethof, Rowlands, Sibul, Skudrzyk, Snowdon, Thompson, Tichy, and Wilson.

Graduate Faculty: Associate Members Bienvenue, Farwell, Frost, Lawther, Macaluso, Maynard, O. H. McDaniel, S. T. McDaniel, Miller, Prout, Ricker, and Stuart.

The aim of this intercollege program is to enable the student interested in acoustics to obtain an integrated program of courses covering the fundamentals of acoustical science and the biological, communications, and engineering applications of acoustics.

Programs are arranged through a selection of appropriate courses offered by several departments in the colleges of Science, Engineering, Education, and Arts and Architecture, as well as those specifically in the area of acoustics.

Areas of concentration include acoustic signal processing, architectural and building acoustics, noise and vibration, physical acoustics, speech and hearing, and underwater acoustics. Thesis research in the various areas may be conducted in relevant departments and in the Applied Research Laboratory.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by competence in the use of computer language, as well as a reading knowledge of a foreign language.

Entering students should hold a bachelor's degree in physics, biology, engineering, architecture, mathematics, psychology, speech and hearing, or in a closely related field; and they should have had at least one year of physics and mathematics including integral calculus. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

In addition to the acoustics courses listed below, the following courses on acoustics and closely related areas are available: Aersp. 412, 444, 506, 511, 515, 516, 517; A.E. 458, 542; E.E. 459, 560, 561, 562; E.Mch. 401, 412, 516, 521, 522, 524A,B, 525, 527, 528, 570; M.E. 458, 522; Phys. 443, 533; Sp.Com. 413, 431; S.P.A. 430, 434, 522, 530, 531, 532, 534.

ACOUSTICS (ACS)

- 401. GENERAL ACOUSTICS (3)
- 402. FUNDAMENTALS OF ACOUSTICS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

*A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department or program offering the course.

A department or major program may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400- and 500-series courses an individual student may schedule fewer credits than the maximum number but in no case more than the maximum number authorized.

All courses listed under graduate major programs may not be required in the particular major.

- 511. UNDERWATER SOUND PROPAGATION (3) Theoretical and empirical treatment of sound propagation in the ocean, including effects of the environment, characteristics of targets, and transducers.
- 512. SONAR ENGINEERING (3) Theoretical and empirical treatment of problems related to the use of underwater sound in target detection and ranging.
- 513. MODERN ACOUSTIC SIGNAL PROCESSING (3) Probability review, representation of signals, noise processes, optimum filtering, ambiguity functions, linear and nonlinear signal processing, application to sonar systems.
- 514. ELECTROACOUSTIC TRANSDUCERS (3) The theory, design, and calibration of passive, linear, reciprocal electroacoustic transducers for use in both air and water media. Prerequisite: Phys. 443.
- 515. ACOUSTICS IN FLUID MEDIA (3) Wave propagation in stationary and moving fluids; acoustic radiation and scattering; standing waves in ducts and cavities. Prerequisites: E.Mch. 524A, Phys. 443.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

ADMINISTRATION (ADMIN)

ROBERT J. BROWN, *In Charge of the Graduate Program in Administration at Capitol Campus*
 Middletown, PA 17057
 717-948-6140

Degree Conferred: M.Adm.

Graduate Faculty: Senior Members Dexter, Gilmore, and Murty.

Graduate Faculty: Associate Members Blumberg, R. Brown, T. Brown, Chisholm, G. Cole, DeRooy, Foeller, Frey, McKenna, Murti, Poore, and Redington.

This program is intended to meet the professional needs of practicing and potential administrators. Options are available in business administration and engineering administration. The business administration option is intended for those students who desire to pursue an administrative career in commerce, business, or industry. The engineering administration option is intended for students who wish to include courses in engineering and operations research as part of their program.

To obtain the degree three foundation courses must be satisfied, and a program of 33-47 credits must be completed. Research competence will be demonstrated by completion of the master's project. Students must register for Bus. 554 (Master's Project) for a total of 3 credits before, or at the same time as, they register for the last 6 credits of other course work.

For admission to the Master of Administration program, the student must have a baccalaureate degree from an accredited institution. Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

Applicants are required to take the Graduate Management Admissions Test.

The program is offered only at the Capitol Campus.

COURSES*

ADMIN. 486. APPLICATIONS OF STATISTICAL COMPUTER PACKAGES (1) Selection and application of computer packages for statistical analysis; construction and modification of files; design of program statements. Prerequisite: 3 credits in basic statistics.

*Course descriptions not given below can be found under the designated field of study.

ADMIN. 500. ADMINISTRATIVE THEORY (3) History, significance and functions of administration, theories of leadership, authority, decision making, rationality, and efficiency.

ADMIN. 505. PERSONNEL MANAGEMENT (3) Problems in effectively selecting, utilizing, and developing human resources from the viewpoint of the total organization — both private and public.

ADMIN. 510. ORGANIZATION BEHAVIOR (3) Examination of concepts of human behavior in formal organizations, systems analysis, conceptual models, and decision processes.

ADMIN. 515. LABOR MANAGEMENT RELATIONS (3) Labor relations issues; collective bargaining agreement, negotiations, and administration; legal framework of collective bargaining; labor relations in larger social context. Prerequisite: Admin. 500.

ADMIN. 520. ADMINISTRATIVE MODELS (3) Formulation and solution of decision models for administrative problems. Analysis of decision making under certainty, risk, and uncertainty. Prerequisites: Bus. 492, and 3 credits in statistics.

ADMIN. 552. MULTIVARIATE STATISTICAL ANALYSIS (3) Application of statistical methods for analyzing the relationships between two or more variables, such as multiple regression. Prerequisite: 3 credits in statistics and Admin. 486.

ADMIN. 556. ECONOMIC AND BUSINESS FORECASTING (3) Application and evaluation of methods for forecasting regional economic change and business activity. Prerequisites: Bus. 380, Econ. 310.

ADMIN. 560. SAMPLING THEORY AND PRACTICE (3) Study of scientific method of obtaining representative samples, collection of information, techniques of estimation. Prerequisite: Bus. 493.

ADMIN. 561. MANAGEMENT INFORMATION SYSTEMS (3) Design and implementation of information systems directed at aiding decision making in organizations. Prerequisites: Admin. 386, Bus. 492, 493, Econ. 410; either Admin. 500 or 510.

ADMIN. 589. SMALL BUSINESS MANAGEMENT PRACTICUM (1-3) Advanced study and practice in small business management through field assignments with cooperating firms to analyze and solve managerial problems.

ADMIN. 590. COLLOQUIUM (1-3)

ADMIN. 596. INDIVIDUAL STUDIES (1-6)

ADMIN. 597. SPECIAL TOPICS (1-6)

BUS. 522. OPERATIONS MANAGEMENT (3) Integration and application of decision making to operational and policy problems within the business firm. Prerequisite: Admin. 520.

BUS. 530. FINANCIAL MANAGEMENT (3) Theory and techniques of financial management. Cover analysis, planning and control; sources of funds; allocation of funds; special situation analysis. Prerequisites: Admin. 520, Bus. 494.

BUS. 540. FINANCIAL AND MANAGERIAL ACCOUNTING (3) Fundamental financial and managerial accounting concepts and issues from the viewpoint of the report user. Prerequisite: 6 credits of introductory accounting.

BUS. 554. MASTER'S PROJECT (1-3) Development of an original master's project in the student's area of professional interest.

BUS. 570. MARKETING MANAGEMENT (3) Analysis of management's marketing problems, including marketing analyses, pricing, channels of distribution, promotion, competition, product strategies, and marketing research.

BUS. 571. CONSUMER BEHAVIOR (3) Factors influencing buyer behavior; contributions of the behavioral sciences to the study of selected phenomena. Prerequisite: Econ. 410.

BUS. 584. GOVERNMENT AND BUSINESS (3). Theory, practice, and impact of government regulation of business. Prerequisite: Econ. 410 or 417.

*BUS. 588. BUSINESS POLICY FORMULATION (3) Analysis of administrative problems from a total organization viewpoint. Case studies of actual organizations are used for analysis. Prerequisites: all core and tool courses.

BUS. 597. SPECIAL TOPICS (1-6)

B.LOG. 538. LOGISTICS SYSTEMS MANAGEMENT (3)

B.LOG. 541. SOCIOECONOMIC ANALYSIS IN TRANSPORTATION (3)

I.B. 501. THE INTERNATIONAL ENVIRONMENT (3)

I.E. 508. OPERATIONS RESEARCH: INVENTORY MODELS (3)

I.E. 509. OPERATIONS RESEARCH: WAITING LINE MODELS (3)

I.E. 510. MATHEMATICAL PROGRAMMING (3)

AEROSPACE ENGINEERING (AERSP)

BARNES W. McCORMICK, *Head of the Department*
233 Hammond Building
814-865-2569

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Eisenhuth, Holl, Kaplan, Lakshminarayana, McCormick, Parkin, Phillips, and York.

Graduate Faculty: Associate Members Hoffman, Morris, Smith, and Thompson.

Opportunities are available for graduate study in the following areas: low-speed aerodynamics, V/STOL aircraft, turbulence, astrodynamics, turbomachinery, aeroacoustics, plasma dynamics, rarefied gas dynamics, hydrodynamics, stability and control of aerospace vehicles, aeroelasticity, and aerospace structures.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by providing proof of mature and meaningful knowledge in a cultural subject of broad significance as a substitute for one of these languages, or by a comprehensive knowledge of one foreign language.

The entering student must hold a bachelor's degree in physical science, mathematics, or engineering and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if not already completed. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

AEROSPACE ENGINEERING (AERSP)

402. AEROSPACE DESIGN (1-3)

Unit A. CONCEPTUAL DESIGN (1)

Unit B. PRELIMINARY DESIGN (1)

Unit C. DETAILED DESIGN (1)

407. AERODYNAMICS OF V/STOL AIRCRAFT (3)

410. AEROSPACE PROPULSION (3)

411. AEROELASTICITY (3)

412. TURBULENT FLOW (3)

413. STABILITY AND CONTROL OF AIRCRAFT AND MISSILES (3)

415. PHYSICAL GAS DYNAMICS (3-6)

*Course to be taken during student's last term — recommend tool courses be completed.

416. INTRODUCTION TO RESEARCH AND DESIGN (1)
 417. AEROSPACE THESIS (2)
 420. PRINCIPLES OF FLIGHT TESTING (3)
 421. (M.E. 421) INTERMEDIATE VISCOUS FLOW (3)
 425. THEORY OF FLIGHT (3)
 430. SPACE PROPULSION AND POWER SYSTEMS (3)
 444. NOISE POLLUTION OF FLUID DYNAMIC ORIGIN (3)
 450. ORBIT AND ATTITUDE CONTROL OF SPACECRAFT (3)
 496. INDEPENDENT STUDIES (1-12)
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504. AERODYNAMICS OF V/STOL AIRCRAFT (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aersp. 407.
 505. AERO- AND HYDROELASTICITY (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.
 506. CAVITATION (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.
 507. THEORY AND DESIGN OF TURBOMACHINERY (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.
 508. FOUNDATIONS OF FLUID MECHANICS (3) Mathematical review, fluid properties, kinematics, conservation laws, constitutive relations, similarity principles, the boundary layer, inviscid flow, vorticity dynamics, wave motion.
 509. DYNAMIC OF IDEAL FLUIDS (3) Irrotational flow theory, two-dimensional and axisymmetric flows, airfoil theory, complex variables, unsteady phenomena; flow with vorticity, finite wing theory. Prerequisite: Aersp. 508.
 510. COMPRESSIBLE FLOW (3) Classification and solution of compressible flow problems, high speed gasdynamics, unsteady motion, transonic and hypersonic flows, atmospheric reentry.
 511. AERODYNAMICALLY INDUCED NOISE (3) Review of fluid mechanics. General theory of aerodynamic sound. Noise radiation from jets, boundary layers, rotors and fans. Structural response.
 512. VISCOUS FLOW (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.
 514. STABILITY OF LAMINAR FLOWS (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.
 515. FOUNDATIONS OF TURBULENCE (3) The mathematics underlying turbulence theory: descriptions, kinematics of stochastic fields; techniques of solution of linear and some nonlinear problems.
 516. HOMOGENEOUS TURBULENCE (3) Dynamics: production, spectral transfer, dissipation, decay of energy; similarity theories.
 517. INHOMOGENEOUS TURBULENCE (3) Dynamics: similarity, structural hypotheses; spatial, spectral budget of energy in a number of classical flows.
 518. DYNAMICS AND CONTROL OF AEROSPACE VEHICLES (3) Dynamical problems of aircraft and missiles including launch, trajectory, optimization, orbiting, reentry, stability and control, and automatic control. Prerequisite: Aersp. 413 or 450.
 550. ASTRODYNAMICS (3) Applications of classical celestial mechanics to space flight planning. Determination and construction of orbital parameters by approximation methods. Perturbation techniques. Prerequisite: Aersp. 450 or Astro. 460 or E.Mch. 410 or Phys. 419.
 590. COLLOQUIUM (1-3)
 596. INDIVIDUAL STUDIES (1-6)
 597. SPECIAL TOPICS (1-6)
 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

AGRICULTURAL ECONOMICS (AG EC)

JOHN W. MALONE, JR., *Head of the Department of Agricultural Economics and Rural Sociology*
6 Weaver Building
814-865-5461

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Epp, Frey, Gamble, Hallberg, Herrmann, Hutton, Janšma, Madden, Malone, McAlexander, Partenheimer, Pasto, Schutjer, and Stemberger.

Graduate Faculty: Associate Members Alter, Beierlein, Cordes, Crowley, Daugherty, Dum, Dunn, Fuller, Goode, Henson, Smith, Weaver, and Young.

The graduate program emphasizes economic theory and analytical techniques in the fields of farm management, production economics, agricultural marketing, resource economics, rural development, agricultural policy and prices, and in international agricultural trade and development.

There is no foreign language requirement for the Ph.D. degree; rather, the student must satisfactorily complete courses in economic theory and quantitative methods.

Students entering the M.S. program should have 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either field. Students entering the Ph.D. program should have successfully completed courses in intermediate micro- and macroeconomic theory, in differential and integral calculus and linear algebra, and in introductory statistics. Students are permitted to enter the M.S. and Ph.D. programs with deficiencies but must pass courses to eliminate deficiencies as soon as possible.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. TOEFL scores are required, and Graduate Record Examination scores are optional, for applicants whose first language is not English. All other applicants are required to submit Graduate Record Examination scores.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 239).

Students may qualify for admission to the program in population issues consisting of interdisciplinary course work with special emphasis on the economic, social, and geographic issues arising from the dynamics of population change.

AGRICULTURAL ECONOMICS (AG EC)

- 407. FARM PLANNING AND FINANCIAL MANAGEMENT (3)
- 410. AGRICULTURAL REAL ESTATE APPRAISAL (3)
- 420. AGRICULTURAL PRICES (3) *Stemberger*
- 421. LAND ECONOMICS (3) *Gamble*
- 422. LAND AND WATER RESOURCE POLICY (3) *Alter*
- 450. INTERNATIONAL AGRICULTURAL TRADE AND DEVELOPMENT (3) *Schutjer*
- 460. INDUSTRIAL ORGANIZATION IN FOOD PROCESSING AND DISTRIBUTION (3) *Dunn*
- 461. DECISION MAKING IN AGRICULTURAL MARKETING FIRMS (3) *Beierlein*
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 500. SEMINAR IN AGRICULTURAL ECONOMICS (1-6) Review of current literature and problems.
- 501. ECONOMICS OF COMMERCIAL AGRICULTURE (3) Application of economic concepts to problems and policies involving agricultural firms, the agricultural industry, and the general agricultural economy. Prerequisite: Econ. 502.
- 502. ECONOMICS OF NATURAL RESOURCES AND RURAL DEVELOPMENT (3) Emphasis will be placed on the application of economic concepts to problems and policies in rural areas. Prerequisites: Econ. 502, 503. *Goode*

504. SEMINAR IN AGRICULTURAL POLICY (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy making. Prerequisites: Ag.Ec. 420, Econ. 405. Odd years. *Hallberg*
505. ADVANCED AGRICULTURAL STATISTICS (3) Multiple correlation, curve fitting, analysis of variance, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics.
507. SEMINAR IN FARM MANAGEMENT (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ. 14. *Partenheimer*
509. CONCEPTS OF ECONOMETRIC THEORY (3) Concepts underlying the application of econometric methods to economic problems; identification and multiple equation models; hypothesis testing and decision theory. Prerequisites: Econ. 502, 503.
514. SURVEY RESEARCH TECHNIQUES IN AGRICULTURAL ECONOMICS (3) Survey methods and design of samples for obtaining economic data from business-unit and household populations. Prerequisite: Ag. 400. Odd years.
520. FARM PRICE ANALYSIS (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. Odd years. *Weaver*
524. RESOURCE ECONOMICS (3) Economic aspects of resource use and development: economic growth, land-use planning and control, conservation, resource investment criteria and policies. Prerequisite: Ag.Ec. 421 or 422. *Epp*
525. RESEARCH METHODS IN RURAL SOCIAL SCIENCES (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences.
527. SEMINAR IN APPLIED QUANTITATIVE METHODS (1-4) *Beierlein*
534. AGRICULTURAL PRODUCTION ECONOMICS (2) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change. Prerequisite: Econ. 502. Even years. *Dunn*
571. SEMINAR IN LAND AND WATER RESOURCE ECONOMICS (3) Critical review of research in resource economics; consideration of special topics in resource use. *Goode*
596. INDIVIDUAL STUDIES (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

AGRICULTURAL EDUCATION (AG ED)

GENE M. LOVE, *Head of the Department*
102 Armsby Building
814-865-1688

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Curtis, Howell, Love, and Stinson.

Graduate Faculty: Associate Members Evans, Heinsohn, Lindley, Mortensen, Morton, and Yoder.

Graduate programs emphasize the professional improvement of teachers and of agricultural extension personnel with education responsibilities. They provide advanced preparation for employment in administration, supervision, teaching including teacher education, and research in agricultural education and related fields. A minor may be taken in an area of agricultural science, technology, or in general studies. Programs may include courses needed for certification in other fields of education. Successful completion of one year of teaching or equivalent professional experience is required prior to completion of the M.S. or M.Ed. degree.

There are no foreign language requirements for the Ph.D. in agricultural education; however, Engl. 418 and Sp.Com. 212 or equivalent communication courses are required.

Admission to a doctoral program requires (1) a 3.00 grade-point average for graduate work, (2) a minimum of two years of successful public, private, or extension teaching experience before the degree is completed, (3) evidence of ability to write a scholarly paper or thesis, and (4) a teaching-level competence in English.

Prerequisite for admission to a master's program is a minimum of 18 credits in professional education courses — including educational psychology and student teaching — or certification as a teacher of agriculture or equivalent professional experience. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission to M.S. or M.Ed. programs. The best-qualified applicants for all degrees will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point averages may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL EDUCATION (AG ED)

400v. EDUCATIONAL PROGRAMS IN AGRICULTURE FOR DEVELOPING COUNTRIES (3)

418v. SURVEY OF VOCATIONAL EDUCATION IN AGRICULTURE (1-4)

420v. INSTRUCTIONAL MEDIA IN AGRICULTURE (1-6)

422v. SUPERVISION OF VOCATIONAL EDUCATION IN AGRICULTURE (1-4)

424v. OCCUPATIONAL GUIDANCE IN AGRICULTURAL INDUSTRY (1-4)

426v. ADULT EDUCATION IN AGRICULTURE (1-4)

430v. AGRICULTURAL EDUCATION INTERNSHIP (1-10)

434v. AGRICULTURAL DEVELOPMENTS (1-6)

440. COMMUNICATION METHODS AND MEDIA IN AGRICULTURE (3)

450. METHODOLOGY OF EXTENSION EDUCATION (3)

490, 490v. COLLOQUIUM (1-3)

496, 496v. INDEPENDENT STUDIES (1-12)

497, 497v. SPECIAL TOPICS (1-6)

501v. AGRICULTURAL EDUCATION IN THE UNITED STATES (1-3) Historical development, social and philosophical foundations, and current status in relation to the total vocational-technical education program.

502v. TEACHING AGRICULTURE (1-3) Vocational education objectives, learning theory, class instruction, cooperative occupational experience, and evaluation.

508v. ADMINISTRATION AND SUPERVISION OF AGRICULTURAL EDUCATION (1-3) Administration of state and district systems of vocational-technical education; supervision of teachers of agriculture.

509v. TEACHER EDUCATION IN AGRICULTURE (1-6) Organization and administration of university programs of teacher education in agriculture, including preservice preparation, continuing education, research, and other services.

520v. SCIENTIFIC METHOD IN THE STUDY OF AGRICULTURAL EDUCATION (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education.

521v. SCIENTIFIC METHOD IN THE STUDY OF AGRICULTURAL EDUCATION (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems.

524v. PROGRAM DEVELOPMENT IN AGRICULTURAL EDUCATION (1-3) Analysis of occupational needs of students and employment prospects; organization of courses of study and other activities of teachers.

530. AGRICULTURAL COLLEGE TEACHING (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, techniques of teaching, and measurement of results of teaching.

590, 590v. COLLOQUIUM (1-3)

596, 596v. INDIVIDUAL STUDIES (1-6)

597, 597v. SPECIAL TOPICS (1-6)

AGRICULTURAL ENGINEERING (AG E)

HAROLD V. WALTON, *Head of the Department*
250 Agricultural Engineering Building
814-865-7792

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bartlett, Morrow, Persson, Stephenson, and Walton.

Graduate Faculty: Associate Members DeTar, Hilton, Hoover, Jarrett, Keppeler, Kjelgaard, Schroeder, and Shaw.

Graduate programs are available in the areas of the physical properties of biomaterials, protected plant and animal production, food and engineering, agricultural structures, agricultural byproduct utilization, agricultural systems engineering, biomass energy conversion, alternative energy sources, agronomic crop mechanization, forage and animal interaction, horticultural engineering, microclimate modification, soil dynamics, and infiltration, drainage, and irrigation.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by either (1) 9 credits of courses in an approved sequence or (2) a foreign language. Prior approval by the Ph.D. Advisory Committee must be obtained to study a foreign language other than French, German, Russian, or Spanish.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are controlled environmental chambers, plant growth structures for modified atmosphere, a general-purpose analog computer, data processing systems including remote job entry for access to University computer facilities, and laboratories for research on physical properties of agricultural materials. Special equipment is available for physical properties work, including Instron and Ametek testing machines complete with environmental chambers and data acquisition systems, a polariscope for photoelastic stress analysis, triaxial testing equipment, and other unique and specially designed testing facilities. Special facilities outside the Agricultural Engineering Building include a mushroom research and demonstration facility, an anaerobic digester for methane gas generation, and the facilities of a 1,525-acre agricultural research center for cooperative work with agronomic and horticultural production systems.

Prerequisite to major work is the completion of an undergraduate major in engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL ENGINEERING (AG E)

401. FARM MECHANICS FOR TEACHERS OF VOCATIONAL AGRICULTURE (1½-9)
402. FUNCTIONAL DESIGN OF AGRICULTURAL STRUCTURES (3)
403. PHYSICAL PROPERTIES OF AGRICULTURAL MATERIALS (3)
404. AGRICULTURAL MACHINERY (3)
405. AGRICULTURAL PROCESS ENGINEERING (3)
407. SOIL WATER ENGINEERING (3)
408. INSTRUMENTATION FOR AGRICULTURAL PRODUCTION AND PROCESSING (3)
409. AGRICULTURAL SYSTEMS ENGINEERING (3)
410. POWER FOR AGRICULTURAL SYSTEMS (3)
412. PHYSICAL PROCESSES IN FOOD MANUFACTURING I (3)
413. PHYSICAL PROCESSES IN FOOD MANUFACTURING II (3)
414. PHYSICAL PROCESSES IN FOOD MANUFACTURING III (2)
420. SEMINAR (1)
423. PHYSICAL AND RHEOLOGICAL MEASUREMENTS ON BIOMATERIALS (3)
424. FARM MACHINERY MANAGEMENT (3)
457. LAND WASTE DISPOSAL (3)

- 490. AGRICULTURAL MECHANIZATION SEMINAR (1)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 500. ADVANCED ELECTRO-AGRICULTURE (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.
- 501. ADVANCED FARM MACHINERY (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.
- 502. FARM STRUCTURES PROBLEMS (1-6) Analysis of farm structures design problems.
- 503. PHYSICAL PROPERTIES OF PLANT AND ANIMAL PRODUCTS (3) Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.
- 505. EXPERIMENTAL AND APPLIED INSTRUMENTATION (4) The theory and application of electronics for instrumentation and experimental research.
- 507. PROBLEMS IN SOIL WATER ENGINEERING (1-6) Analysis of engineering problems relating to irrigation, drainage, or erosion control.
- 509. RESEARCH IN AGRICULTURAL ENGINEERING (1-4)
- 520. AGRICULTURAL ENGINEERING SEMINAR (1-3) Reports on research and special topics.
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

AGRONOMY (AGRO)

JAMES L. STARLING, *Head of the Department*
 117 Tyson Building
 814-865-6541

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Baker, Bollag, Ciolkosz, Cleveland, Cunningham, Duich, Fritton, Hall, Harrington, Heald, Hill, L. Johnson, M. Johnson, Jung, Kendall, Marshall, McKee, Petersen, Pionke, Risius, Rogowski, Shenk, Starling, Templeton, Waddington, and Watschke.

Graduate Faculty: Associate Members Baylor, Berg, Cole, Fox, Gustine, Hartwig, Hatley, Knievel, Lanyon, Pennock, and Stringer.

Students may specialize in soil science, crop science, or soil and crop management. Soil science specialties include genesis and morphology, chemistry, biochemistry, fertility, mineralogy, physics, and remote sensing. Crop science specialties include breeding and genetics, crop quality, crop and weed ecology, and physiology.

The communication and foreign language requirement for the Ph.D. degree may be met either by demonstrating a knowledge of at least one foreign language or by completing at least 6 credits of course work in an area of English communications approved by the student's advisory committee.

Prerequisites for major work in agronomy vary with the area of specialization and the degree sought, but courses in chemistry, mathematics, physics, geology, basic and applied biological sciences, and English communication skills are required. Applicants for the M.S. degree should have a baccalaureate degree including 76 credits of basic and applied natural sciences. For the M.Agr. degree program, an applicant must present a baccalaureate degree in agricultural or forest science. Admission to the Ph.D. program requires an M.S. or equivalent degree, and 100 credits (including credits of the baccalaureate degree) of basic and applied natural sciences. Students who lack some of the prerequisite courses may be admitted but are required to take these courses without degree credit.

A minimum junior-senior grade-point average of 3.00 is required for admission to the agronomy master's degree programs. In addition, a grade-point average of 3.00 is required in all courses in the biological and physical sciences regardless of when taken. Exceptions to these requirements may be made for students with special backgrounds, abilities, and interests. Applicants for the Ph.D. program will be evaluated principally on the quality of work completed in previous graduate programs. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

AGRONOMY (AGRO)

401. SOIL COMPOSITION AND PHYSICAL PROPERTIES (3) *Fritton and Johnson*
 402. CHEMISTRY OF SOILS AND FERTILIZERS (3) *Fox*
 410. CROP SCIENCE (3) *Knievel*
 411. BREEDING OF FIELD CROPS (3) *Cleveland*
 415. SOIL MORPHOLOGY, MAPPING, AND LAND USE (3) *Petersen*
 416. SOIL GENESIS AND CLASSIFICATION (3) *Ciolkosz*
 417. FOREST SOILS (3) *Pennock*
 419. SOIL PROPERTIES (4) *Baker*
 420. AGRONOMIC CASE STUDIES IN SOIL, PLANT, AND WATER MANAGEMENT (3) *Lanyon*
 422. CONSERVATION OF SOIL AND WATER RESOURCES (3) *Cunningham*
 423. FORAGE CROP MANAGEMENT (3) *Stringer*
 425. FIELD CROP MANAGEMENT (3) *Pfeifer*
 430. INTERNSHIP (1-5)
 438. PRINCIPLES OF WEED CONTROL (3) *Hartwig*
 439. HERBICIDE PROPERTIES AND MODE OF ACTION (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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501. SOIL FERTILITY (3) Soil-plant relations emphasizing recent concepts of ion accumulation by plants as affected by soil conditions and plant physiology. Prerequisites: Agro. 402, Biol. 441. *Hall*.
 506. SOIL PHYSICAL CHEMISTRY (4) Colloidal chemistry of soils emphasizing ion adsorption, double-layer theory, diffusion, and water properties. Prerequisites: Agro. 419; Bioch. 425 or Chem. 451. *Baker*
 507. SOIL PHYSICS (3-4) Soil physical properties emphasizing water, heat, gas, and ion movement in unsaturated soils. Laboratory included with 4 credits. Prerequisites: 6 credits each of calculus, physics, and soils. *Fritton*
 509. METHODS OF GENETIC ANALYSIS (3) Methods of qualitative genetics. Tests of hypotheses, homogeneity, linkage detection, calculations of recombination values, monosomic analysis, and tetrasomic inheritance. Prerequisite: 6 credits of genetics or plant breeding. *Cleveland*
 510. CYTOGENETICS IN PLANT BREEDING (3) Chromosomal heredity of agricultural plants. Chromosome morphology; cytogenetic behavior of aneuploids, haploids, auto- and allopolyploids, and interspecific hybrids. Prerequisite: 6 credits of genetics including 3 credits of cytogenetics or cytology. *Cleveland*
 511. BIOMETRICAL PLANT BREEDING (3) Quantitative genetics of plant populations; applications to breeding methodology and selection. Prerequisites: Agro. 512 and 3 credits of plant breeding. *Hill and Risius*
 512. FIELD PLOT TECHNIQUE (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Ag. 400 or Stat. 200. *Risius*
 515. NUTRITIVE VALUE OF CROP PLANTS (3) Biochemical, physiological, genetic, and morphological nature of crop plants related to animal response. Laboratory includes nutritive evaluation procedures. Prerequisites: 3 credits of crop production and 6 credits of biochemistry and/or nutrition. *Shenk*
 517. CROP ECOLOGY AND PHYSIOLOGY (3) Ecological and physiological factors affecting the productivity of crop plants. Prerequisite: Agro. 410. *McKee*

518. RESPONSES OF CROP PLANTS TO ENVIRONMENTAL STRESS (3) Physiological and ecological aspects of the response of crop plants to environmental stresses in establishment, persistence, and reproduction. Prerequisite: Agro. 410. *McKee*
519. NATURE OF SOIL MINERALS (3) Constituent minerals of soils: modern methods for identification; relations to soil formation and agricultural practices. Prerequisite: Agro. 401. *Johnson*
545. THE APPLICATION OF STATISTICS TO FIELD EXPERIMENTS (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. *Risius and Shenk*
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

AMERICAN STUDIES (AM ST)

IRWIN RICHMAN, *In Charge of the Graduate Program in American Studies*
The Capitol Campus, Middletown, PA 17057
717-948-6189

Degree Conferred: M.A.

Graduate Faculty: Senior Members R. Graham, Gross, Lear, Richman, Tischler, and G. Wolf.

Graduate Faculty: Associate Members Barton, Churchill, T. Graham, Milspaw, Molovinsky, and Patterson.

This program emphasizes the study of American society as a whole, not as interpreted by a single discipline, but in the larger context of a culture. The purpose of the program is to provide the student with the opportunity to acquire knowledge and understanding within any of the following areas: ethnic composition and demographic problems of the American people; regional characteristics; the technological base of American civilization; economic, political, and social institutions; the media of communication; artistic expression, particularly in art, architecture, literature, and music; philosophy and values; and the dynamics and interrelationships of all of these.

The student is required to take a minimum of 30 credits, including at least 18 credits in the 500 series. A maximum of 24 of these 30 credits shall be taken within the program area. An original, scholarly master's paper or creative production initiated by the student, supervised by an appropriate professor, and judged by a committee is required. One to 6 credits can be accumulated during work on the master's production.

For admission to the master's program, a student must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. Social sciences and the humanities are not required as prerequisites, though it is anticipated that students will have had work in these areas. The application, transcripts, and a letter outlining personal goals and reasons for applying for the program should be sent directly to the Graduate Office, The Capitol Campus, Middletown, PA 17057.

REQUIRED COURSES

AM.ST. 500. THEORY AND METHODS (3) Study of the methods and materials of American Studies scholarship, compilation of bibliographies, the writing of scholarly papers, and proper documentation.

AM.ST. 580. PROJECTS IN AMERICAN STUDIES (1-6) Independent exploration within American Studies; evidenced by major paper, film, exhibition, or specialized examination.

APPROPRIATE COURSES may be taken from the following list and from 500-level courses in other fields with the concurrence of the student's adviser.

AM.ST. 511. PIVOTAL BOOKS (3-9) Exploration of a number of books which have been particularly influential in shaping thinking about American civilization.

AM.St. 530. TOPICS IN AMERICAN FOLKLORE (3) A detailed exploration of aspects of folklore and folklife in America.

AM.St. 533. AMERICAN CIVILIZATION IN THE EIGHTEENTH CENTURY (3-9) Detailed investigation of specific topics in eighteenth-century American civilization.

AM.St. 534. AMERICAN CIVILIZATION IN THE NINETEENTH CENTURY (3-9) Representative interdisciplinary investigation of social, historical, economic, and aesthetic forces predominant in nineteenth-century America.

AM.St. 535. AMERICAN CIVILIZATION IN THE TWENTIETH CENTURY (3-9) Detailed investigation of specific periods or topics in twentieth-century American civilization.

AM.St. 570. TOPICS IN AMERICAN ART (1-6) Various themes within the American arts will be explored under this rubric.

AM.St. 575. MUSEUM INTERNSHIP (3) A supervised museum internship experience featuring a "hands-on" introduction into aspects of the curatorial profession. Prerequisite: permission of instructor.

AM.St. 590. COLLOQUIUM (1-3)

AM.St. 596. INDIVIDUAL STUDIES (1-6)

AM.St. 597. SPECIAL TOPICS (1-6)

ADDITIONAL COURSES may be taken from the following list and from 400-level courses in other fields with the concurrence of the student's adviser.*

AM.St. 400. AMERICAN COLONIAL EXPERIENCE

AM.St. 401. AMERICAN REVOLUTION AND EARLY NATIONAL EXPERIENCE

AM.St. 403. INTELLECTUAL FOUNDATIONS OF AMERICAN CULTURE

AM.St. 431. THE AMERICAN CHARACTER

AM.St. 442. AMERICAN FOLKLORE

AM.St. 445. AMERICAN PHILOSOPHY

AM.St. 451. CIVIL WAR AND RECONSTRUCTION

AM.St. 452. THE AMERICAN RENAISSANCE

AM.St. 453. THE GILDED AGE AND THE PROGRESSIVE IMPULSE

AM.St. 454. AMERICA'S POLITICAL PARTIES

AM.St. 456. MASS CULTURE: THE POPULAR ARTS IN AMERICA

AM.St. 457. IMMIGRANTS AND AMERICANS

AM.St. 458. CONTEMPORARY AMERICA

AM.St. 459. AMERICA'S COMING OF AGE 1914-1939

AM.St. 460. AMERICAN ART AND ARCHITECTURE

AM.St. 463. AMERICAN MUSIC

AM.St. 469. AMERICAN INDIAN ETHNOLOGY

AM.St. 470. REGIONALISM IN AMERICA

AM.St. 474. (Econ. 474) AMERICAN ECONOMIC DEVELOPMENT

AM.St. 479. UNITED STATES DIPLOMATIC HISTORY

AM.St. 480. MUSEUMS AND CULTURE

AM.St. 491. SEMINAR IN AMERICAN CULTURE

AM.St. 496. INDEPENDENT STUDIES (1-12)

AM.St. 497. SPECIAL TOPICS (1-6)

PUB.PL. 403. CONTEMPORARY U.S. FOREIGN POLICY

PUB.PL. 470. THE PRESIDENCY AND THE EXECUTIVE PROCESS

*Descriptions of these courses may be found in *The Capitol Campus Catalog*.

ANATOMY (ANAT)

BRYCE L. MUNGER, *Chairman of the Department*
The Milton S. Hershey Medical Center
Hershey, PA 17033
717-534-8650

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baird, Leure-duPree, Munger, Page, Pubols, and Zagon.

The graduate program emphasizes the general areas of gross anatomy, histology/cytology, neuroanatomy/neurophysiology, or appropriate combinations of these areas. Approaches offered include morphological (descriptive, comparative, developmental), functional (physiological, chemical), and experimental. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants must provide complete transcripts and two letters of recommendation. Scores from the Graduate Record Examination and a personal interview are desirable.

This program is offered only at The Milton S. Hershey Medical Center.

ANATOMY (ANAT)

501. FUNDAMENTALS OF GROSS ANATOMY I (3) Macroscopic structure of the upper extremity, head, and neck, with emphasis on normal organization, functional correlations, and clinical significance.

502. FUNDAMENTALS OF GROSS ANATOMY II (3) Macroscopic structure of the thorax, abdomen, pelvis, and lower extremity, with emphasis on normal organization, functional correlations, and clinical significance. Prerequisite: Anat. 501.

505. MICROSCOPIC ANATOMY (4) Microscopic organization of tissues and cells; interrelationships of cells; chemical and functional specializations of cells.

510. NEUROBIOLOGY (3) Morphology and function of the sense organs, general organization of the brain, and physiological studies of central nervous system function.

512. HUMAN EMBRYOLOGY (2) A basic study of the development of the human embryo including gamete production and fusion, implantation, and organogenesis.

513. COMPARATIVE MORPHOGENESIS (3) A descriptive and experimental study of vertebrate and invertebrate development.

515. DEVELOPMENTAL NEUROBIOLOGY (2) Development of the nervous system in all aspects.

530. DISSECTION (2-4) Intensive laboratory study of selected regions of the human body. Coverage and credit arranged by consultation.

535. SUBMICROSCOPIC ANATOMY (3) Current literature on molecular and micellar organization of cells and tissues in diverse systems; application of interference and electron microscopy. Prerequisite: Anat. 505.

542. COMPARATIVE NEUROLOGY (3) Topics in functional anatomy and neurophysiology. The comparative approach to the organization of the mammalian nervous system will be stressed. Prerequisite: Anat. 510.

543. SENSORY PROCESSES (3) Morphological, physiological, and psychophysical aspects of mammalian sensory systems; emphasizing somatic, sensory, visual, and auditory systems. May be repeated. Prerequisite: Anat. 510.

545. **COMPARATIVE AUDITORY AND VISUAL ANATOMY (3-5)** An introduction to the morphology and evolution of the vertebrate eye and ear; individualized laboratory work arranged by consultation.
550. **SEMINAR IN QUANTITATIVE OPTICS (3)** Study of the various types of light microscopy instruments and application of these tools to quantitative measurements in biological systems. Prerequisite: Anat. 505.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

ANIMAL INDUSTRY (A I)

G. W. SHERRITT, *Chairman, Graduate Program in Animal Industry*
 325 Animal Industries Building
 814-865-1362

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Baumgardt, Cowan, Hershberger, Long, Sherritt, Sink, Wangsness, Wilson, and Ziegler.

Graduate Faculty: Associate Members Burdette, Cash, Etherton, Hagen, Harpster, King, and Merritt. and Merritt.

Opportunities are available for graduate study and research in breeding and genetics, nutrition and feed technology, physiology, animal management systems, growth and body composition, and meat science. Ruminant, nonruminant, small animal, and wildlife species are available.

The M.Agr. is a professional program designed to prepare individuals for specialist and management positions in county agricultural extension, government, or industry and does not require a thesis. The academic M.S. and Ph.D. programs require a thesis and are designed for those primarily interested in education and research. The requirements of these programs are detailed in the departmental publication, *Requirements of the Graduate Programs in Animal Industry*. The communication and foreign language requirements for the Ph.D. degree may be satisfied by competence in either one foreign language or communications skills.

For admission the student must complete an undergraduate major in animal science or a closely related field. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without graduate degree credit. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

ANIMAL INDUSTRY (A I)

406. **SWINE MANAGEMENT AND PRODUCTION (3)**
407. **ADVANCED HORSE PRODUCTION AND MANAGEMENT (2)**
408. **SHEEP PRODUCTION AND MANAGEMENT (3)**
409. **BEEF PRODUCTION AND MANAGEMENT (3)**
423. **ADVANCED LIVESTOCK SELECTION (2)**
424. **ANIMAL INDUSTRY SEMINAR (1 per term)**
431. **ADVANCED MEAT SELECTION AND GRADING (2)**
496. **INDEPENDENT STUDIES (1-12)**
497. **SPECIAL TOPICS (1-6)**
505. **ADVANCED ANIMAL BREEDING (1-5)** Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: An.Sc. 322.

510. **ANIMAL SCIENCE RESEARCH METHODS (3)** Application of scientific method; experimental design and procedures; analyzing, interpreting, and reporting research results. Prerequisite: Ag. 400.
514. **ANIMAL GROWTH AND DEVELOPMENT (3)** Animal life cycles; nature of growth and development; effects of biological, environmental, social, and psychological variants; homeostasis and organismic theory. Prerequisites: 3 credits in biochemistry and 3 credits in physiology.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

NOTE: See *Animal Nutrition, Physiology, and Food Science*. Also see *Animal Science* under "Other Graduate Courses."

ANIMAL NUTRITION (A NTR)

ROBERT L. COWAN, *Chairman of the Committee on Animal Nutrition*
305 Animal Industries Building
814-863-0669

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baumgardt, Cowan, Hershberger, Kesler, Leach, McCarthy, Mendez, Muller, Scholz, and Wangsness.

Graduate Faculty: Associate Members Etherton, Harpster and Shellenberger.

This is an interdepartmental graduate program designed to enable students to obtain thorough training in animal nutrition. The program is under the direction of a committee composed of graduate faculty members of the Departments of Animal and Dairy Science, Poultry Science, and Veterinary Science, and the Human Performance Research Laboratory. Programs are offered in ruminant and nonruminant nutrition, including: physiology of nutrition; nutritional requirements for productive functions; metabolism of carbohydrates, lipids, proteins, vitamins, and minerals; and regulation of food intake and other metabolic functions.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages.

Undergraduate preparation should include organic and analytical chemistry, physics, biology, and mathematics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiencies without graduate credit.

Students should have an appropriate background and a 3.00 average in the major area and in related sciences for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum requirements may be made for students with special backgrounds, abilities, and interests.

The following nutrition courses are offered by participating departments, and their descriptions may be found under the listings of the respective departments: D.Sc. 511, Pty.Sc. 502, and V.Sc. 535. Courses related to animal nutrition can be found under the following listings in this bulletin: Animal Industry, Biochemistry, Dairy Science, Food Science, Physiology, Poultry Science, and Veterinary Science. For other graduate courses in this subject area see courses listed under Nutrition such as Nutr. 552, 556, and 557.

ANIMAL NUTRITION (A NTR)

401. **PHYSIOLOGY OF NUTRITION (3)**
420. **NUTRITION AND FEED TECHNOLOGY (2)**
421. **APPLIED FEEDING OF BEEF CATTLE AND SHEEP (1)**
422. **APPLIED FEEDING OF DAIRY CATTLE (1)**

- 423. APPLIED FEEDING OF SWINE, POULTRY, AND LABORATORY ANIMALS (1)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501. ENERGY METABOLISM (2) Integration of biochemical and physiological processes in energy metabolism; concepts underlying the application of bioenergetics and calorimetry to metabolism. Prerequisites: 3 credits each in biochemistry and physiology.

503. MICRONUTRIENTS: NUTRITION, METABOLISM, AND FUNCTION (2) Functional approach to the study of vitamins and trace elements in the nutrition and metabolism of animals and man. Prerequisites: 3 credits each in biochemistry, nutrition, and physiology.

505. RUMINOLOGY (3) Physiological, biochemical, and microbiological activities occurring within the rumen and the relation of rumen function to animal response. Prerequisites: at least one course in each of the following areas: animal nutrition, physiology, microbiology, and biochemistry.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

ANTHROPOLOGY (ANTHY)

WARREN T. MORRILL, *Head of the Department*
409 Carpenter Building
814-865-2509

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members P. Baker, Chagnon, Eckhardt, Escobar, Hunt, Michels, Morrill, Sanders, and Webster.

Graduate Faculty: Associate Members T. Baker, Dyke, Hatch, Kurland, and Nydegger.

The master's program is designed to train students in general anthropology. The doctoral program is structured to train students in the following areas of specialization: social anthropology, cultural evolution and ecology, analytic archaeology, archaeological technology, archaeology culture areas, or human biology including human physiology, adaptability, biological determinants of human behavior, demography, and human evolution.

M.A. candidates may submit either a thesis or a term paper. If the latter is chosen, 6 credits in 500-level courses in the major field must be scheduled in lieu of thesis credits. The M.A. degree may be bypassed by exceptional candidates for the Ph.D. degree.

The communication and foreign language requirement for the Ph.D. degree includes a reading knowledge of a foreign language plus an option from among additional foreign languages, field languages, linguistics, and statistics.

Undergraduate preparation must include 12 credits in anthropology and archaeology or their equivalent. A student with an excellent record but who does not meet these requirements may be admitted provided course deficiencies are made up without graduate credit. Students with a 3.00 or higher junior-senior average and with appropriate course backgrounds who have research interests directly related to the special anthropological competences within the department will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ANTHROPOLOGY (ANTHY)

- 400. HUMAN EVOLUTION: THEORY AND PROCESS (3)
- 401. HUMAN EVOLUTION: THE MATERIAL EVIDENCE (3)

402. HUMAN ECOLOGY (3)
405. PRIMATOLOGY (3)
408. DEMOGRAPHIC METHODS IN ANTHROPOLOGY (3)
409. ANALYTIC METHODS LABORATORY (1)
410. OSTEOLOGY LABORATORY (1)
414. SYSTEMATIC INSTRUCTION IN ANTHROPOLOGY (3)
415. (C.F.Ed. 415) ANTHROPOLOGY OF EDUCATION (3)
420. ARCHAEOLOGY OF THE NEAR EAST (3)
421. ARCHAEOLOGY OF THE CENTRAL ANDES (3)
422. ARCHAEOLOGY OF MESO-AMERICA (3)
423. ARCHAEOLOGY OF EASTERN UNITED STATES (3)
424. ARCHAEOLOGY OF AFRICA (3)
440. SOUTH AMERICAN TRIBAL SOCIETIES (3)
441. ETHNOLOGY OF THE ANDEAN REGION (3)
442. EUROPEAN PEASANTRY (3)
444. ETHNOLOGY OF MESO-AMERICA (3)
446. ETHNOLOGY OF NORTH AMERICA (3)
447. ETHNOLOGY OF SUB-SAHARAN AFRICA (3)
448. ETHNOLOGY OF THE MIDDLE EAST (3)
449. ETHNOLOGY OF SOUTHEAST ASIA (3)
450. COMPARATIVE SOCIAL ORGANIZATION (3)
451. ECONOMIC ANTHROPOLOGY (3)
453. (Soc. 453) PRIMITIVE RELIGION (3)
454. POLITICAL ANTHROPOLOGY (3)
455. CULTURE AND PERSONALITY (3)
456. CULTURAL ECOLOGY (3)
457. LANGUAGE IN CULTURE (3)
458. PRIMATE SOCIOBIOLOGY (3)
460. ANTHROPOLOGICAL THEORY (3)
461. METHODS IN CULTURAL ANTHROPOLOGY (3)
462. METHODS IN ARCHAEOLOGY (3)
464. TRIBAL SOCIETIES (3)
471. HISTORY OF ANTHROPOLOGICAL THEORY (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

500. HUMAN EVOLUTION (3) Theoretical problems in analysis of human evolution. Prerequisite: one course in human genetics or physical anthropology.
501. EVOLUTION OF HUMAN BEHAVIOR (3) The application of evolutionary theory to the study of man's structure, function, and culture. Prerequisites: Anthy. 21 or 401, and 3 additional credits in anthropology, sociology, or psychology.
502. HUMAN ECOLOGY THEORY (3) Analysis of interaction of physical, biological, and cultural factors in human adaptation. Prerequisite: 3 credits in physical anthropology.
504. SOCIAL AND CULTURAL CHANGE (3) Theories and methods used in the analysis of social and cultural change.
505. TOPICS IN PRIMATE SOCIOBIOLOGY (3) An advanced seminar on current research and problems in the study of nonhuman primate behavior and ecology. Prerequisite: Anthy. 458.
506. CULTURAL DYNAMICS (3) Survey of the major theories of culture change with special reference to archaeological research.
507. THE BIOLOGY OF HUMAN ADAPTABILITY (3) An exploration of the biological mechanisms which aid man's survival in a variety of environmental settings.
508. RESEARCH PROBLEMS IN CULTURE HISTORY (3-9)

509. SEMINAR IN REGIONAL STUDIES (3-9) Research and analysis in selected world cultural areas, including ecology, prehistory, history, ethnography, and current status.
511. (Hl.Ed. 511) HEALTH IMPLICATIONS IN THE GROWTH AND DEVELOPMENT OF SCHOOL CHILDREN (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems.
513. (Hl.Ed. 513) HEALTH IMPLICATIONS IN MATURITY AND AGING (3) Changes in the human body in maturity and aging; mechanisms of physiologic aging; implications for health and preventive medicine. Prerequisite: Hl.Ed. 511.
- 522-523. ECOLOGICAL THEORY IN ANTHROPOLOGY (3 each) Man's biology, culture history, and culture variation from the ecological perspective. Two-term enrollment required. Prerequisite: 6 credits in anthropology.
530. INDIVIDUAL READINGS IN ANTHROPOLOGY (1-6) Reading or research in selected aspects of general anthropology.
531. INDIVIDUAL RESEARCH IN ANTHROPOLOGY (3-12)
545. SEMINAR IN ANTHROPOLOGY (1-9) Critical analysis of research in selected areas of anthropology.
558. EVOLUTION OF SOCIAL STRUCTURES I (3) Evolution of social organization. Biological and social changes differentiating human and primate societies.
559. EVOLUTION OF STRUCTURES II (3) Major anthropological approaches to study of social organization.
560. ANTHROPOLOGICAL THEORY (3) Theory used in culture — historical, sociological, and psychological interpretations.
561. FIELD METHODS IN ANTHROPOLOGY (3-9) Individual field work in any aspect of anthropology, supervised by staff of professional rank.
562. LABORATORY METHODS IN ANTHROPOLOGY (3-9) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.
563. SEMINAR IN LINGUISTIC ANTHROPOLOGY (3-6) Organized research on special topics in linguistic anthropology.
597. SPECIAL TOPICS (1-6)

ARCHITECTURAL ENGINEERING (A E)

GIFFORD H. ALBRIGHT, *Head of the Department*
101 Engineering A Building
814-865-6394

Degree Conferred: M.S.

Graduate Faculty: Senior Members McLaughlin, Summers, and Tichy.

Graduate Faculty: Associate Members Albright, Flynn, Geschwindner, Gilman, and Wheeler.

Students may specialize in structural analysis and design, environmental control engineering (including energy conservation and energy management in building), solar energy applications, illumination, acoustics, materials of construction, building construction management, computer application to building design and performance, or nuclear defensive and protective construction. The latter area includes shelter planning, effects of nuclear weapons, shelter environmental requirements, analysis and design of blast-resistant structural systems, and integrated engineering requirement for protective construction.

For admission a student must have a strong background in some field of engineering; in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate

preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURAL ENGINEERING (A E)

- 401. ARCHITECTURAL ENGINEERING (3)
- 402. ARCHITECTURAL ENGINEERING (3)
- 403. ARCHITECTURAL ENGINEERING (3)
- 430. ARCHITECTURAL ENGINEERING (3)
- 431. ARCHITECTURAL ENGINEERING (3)
- 439. ARCHITECTURAL ENGINEERING (3)
- 441. INTEGRATION OF ARCHITECTURAL ENGINEERING SYSTEMS (3)
- 454. ENVIRONMENTAL ENGINEERING IN BUILDINGS — DESIGN (3)
- 458. ADVANCED ARCHITECTURAL ACOUSTICS AND NOISE CONTROL (3)
- 464. ADVANCED ARCHITECTURAL ILLUMINATION SYSTEMS DESIGN (3)
- 471. BUILDING CONSTRUCTION ASSEMBLIES (3)
- 472. BUILDING CONSTRUCTION MANAGEMENT I (3)
- 473. BUILDING CONSTRUCTION MANAGEMENT II (3)
- 474. BUILDING COST ANALYSIS (3)
- 475. BUILDING CONSTRUCTION ENGINEERING I (3)
- 476. BUILDING CONSTRUCTION ENGINEERING II (3)
- 477. BUILDING PROJECT ANALYSIS (3)
- 481. ARCHITECTURAL ENGINEERING THESIS (2)
- 482. ARCHITECTURAL ENGINEERING THESIS (2)
- 483. ARCHITECTURAL ENGINEERING THESIS (2)
- 486. PROFESSIONAL ENGINEERING PRACTICE (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

542. ADVANCED PROBLEMS AND RESEARCH IN ARCHITECTURAL ENGINEERING (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems.

545. ARCHITECTURAL ENGINEERING SEMINAR (1-6) Current literature and special problems in architectural engineering; presentation of technical papers.

ARCHITECTURE (ARCH)

RANIERO CORBELLETTI, *Head of the Department*
 308 Sackett Building
 814-865-9535

Degrees Conferred: M.S., M.Arch.

Graduate Faculty: Senior Members Corbelletti, Golany, and Strumillo.

Graduate Faculty: Associate Members Anderson, Hallock, Inserra, and Vollmer.

The Master of Science is an academic degree available to students with training in other design-related fields, as well as to students with a professional degree in architecture reentering the University for study in a speciality. Advanced studies are offered in architecture, urban design, and planning. The student is offered opportunity for independent research and extensive interdisciplinary work under the

guidance of specialists and scholars in technical, cultural, industrial, and social fields. The nonthesis option is available for the M.S. degree.

The Master of Architecture degree program is planned to provide the depth and breadth of knowledge needed to enter the architectural profession and become licensed as a professional architect after the required period of internship. Requirements for admission include the equivalent of 39 credits in design-research work and a statement of purpose concerning the professional aims of the candidate. A portfolio of examples of the student's work must be presented. The nonthesis option is available for the M. Arch. degree. The program is available to candidates holding a B.A. or B.S. degree with a major in architecture, or environmental design, or holding other nonprofessional degrees in architecture.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURE (ARCH)

- 430. DESIGN-RESEARCH II (4-12)
 - 441. ARCHITECTURAL DESIGN ANALYSIS (3)
 - 442. ARCHITECTURAL DESIGN ANALYSIS (3)
 - 443. ARCHITECTURAL DESIGN ANALYSIS (3)
 - 461. ARCHITECTURAL STRUCTURAL SYSTEMS I (3)
 - 462. ARCHITECTURAL STRUCTURAL SYSTEMS II (3)
 - 463. ARCHITECTURAL STRUCTURAL SYSTEMS III (3)
 - 465. ARCHITECTURAL BUILDING MATERIALS (3)
 - 471. ENVIRONMENTAL CONTROL SYSTEMS I (3)
 - 472. ENVIRONMENTAL CONTROL SYSTEMS II (3)
 - 481. ADVANCED ARCHITECTURAL DATA SYSTEMS I (3)
 - 482. ADVANCED ARCHITECTURAL DATA SYSTEMS II (3)
 - 483. SPECIAL PROBLEMS — ARCHITECTURAL DATA SYSTEMS APPLICATIONS (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
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- 515. NEW TOWNS PLANNING SEMINAR (3) Examination of the process, concepts, and structure of new towns planning as a response to contemporary urban-regional development problems.
 - 516. NEW COMMUNITIES SEMINAR (3) Examination and evaluation of the new communities movement in the United States.
 - 517. NEW TOWNS PLANNING PROCESS (3) A systematic study and analysis of the sequence of actions in the new towns planning process.
 - 518. NEW TOWNS RESEARCH SEMINAR (3) Advanced research seminar using comparative case studies of comprehensive contemporary issues of new towns planning. Prerequisites: Arch. 515, 517.
 - 530. ARCHITECTURE I (4-12) Problems in architectural planning and design. Programming and/or implementation methodologies and applications for various environmental design scales.
 - 531. ARCHITECTURE II (4-12) Continuation of Arch. 530 with concentration and specialization options. Prerequisite: Arch. 530.
 - 532. COMPREHENSIVE PLANNING PROCESS STUDIO (4-12) Field case studies in analysis forecasting and projections of urban physical design elements. Preparation of comprehensive plan, regulations, and implementation.
 - 535. NEW TOWNS PLANNING STUDIO (4-12) A team workshop of planning and design of new towns, involving data gathering, surveys, analysis, projection, and implementation.
 - 591. ARCHITECTURAL RESEARCH (2-12) Guided research project.
 - 596. INDIVIDUAL STUDIES (1-6)
 - 597. SPECIAL TOPICS (1-6)

ART (ART)

JERROLD MADDOX, *Director, School of Visual Arts*
102 Visual Arts Building
814-865-0444

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Members Adams, Cook, and Zoretich.

Graduate Faculty: Associate Members DonTigny, Frost, Hessel, Lang, McHale, Porter, Shobaken, Sommese, and Stephenson.

The M.A. program is planned to provide a broad range of experience and study in the visual arts. A thesis in an area of specialization is required. Requirements for admission include a broad undergraduate training in art and the presentation of a portfolio of the applicant's work.

The M.F.A. program is planned to provide professional emphasis in a specific area of art. A creative project and supporting monograph are required. Requirements for admission include 36 credits in studio art with some indication of concentration in a chosen area and a statement of purpose concerning the professional aims of the candidate. A portfolio must be presented.

A portfolio of slides (quality photographs for sculpture applicants), rather than actual work, is requested. A selection of no fewer than twenty examples should be presented. The majority of these should be in the area of the applicant's interest, but the portfolio should also include a lesser emphasis in related areas.

All students accepted for graduate study in art who lack the adequate undergraduate courses or show deficiencies in some area will be required to take additional course work without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ART (ART)

- 411. SEMINAR IN CONTEMPORARY ART (3 per term, maximum of 6)
- 421. ADVANCED DRAWING (3 per term, maximum of 9)
- 425. DRAWING SEMINAR (3 per term, maximum of 6)
- 430. ADVANCED SCULPTURE (3 per term, maximum of 12)
- 448. ADVANCED PRINTMAKING (3 per term, maximum of 12)
- 450. ADVANCED PAINTING (3 per term, maximum of 12)
- 455. ADVANCED PAINTING CRITIQUE (3 per term, maximum of 6)
- 460. ADVANCED WATERCOLOR (3 per term, maximum of 12)
- 465. ADVANCED DESIGN (3 per term, maximum of 9)
- 470. TIME AND SEQUENCE (3)
- 471-472. SENIOR PROBLEMS (3 each)
- 473. GRAPHIC DESIGN SEMINAR (3)
- 480. ADVANCED CERAMIC ARTS (3 per term, maximum of 12)
- 491. PHOTOGRAPHY AND OTHER DISCIPLINES (3 per term, maximum of 12)
- 494. GROUP PROJECTS IN PHOTOGRAPHY (3 per term, maximum of 9)
- 495. CREATIVE PROJECTS IN PHOTOGRAPHY (3 per term, maximum of 12)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. ART RESEARCH (2-6) Original study and practice in art relating to material, concept, or technique.

- 530. ADVANCED SCULPTURE (3-12) Individual projects in sculpture leading to the development of a collection or body of work representative of the artist.

- 545. PRINTMAKING (2-12) Problems in printmaking leading to the development of a collection or body of work representative of the individual artist.

550. **PAINTING (2-12)** Individual problems in painting leading to the development of a collection or body of work representative of the artist.

570. **DESIGN (2-12)** Individual projects in design with special emphasis on professional practice in specialized fields of graphic design.

580. **CERAMICS (2-12)** Experimental problems in ceramics leading to the development of a collection or body of work representative of the individual.

595. **PHOTOGRAPHY (3)** Individual projects in photography leading to the development of a body of specialized work representative of the artist. Prerequisite: 12 credits of Art 495.

ART EDUCATION (A ED)

KENNETH R. BEITTEL, *in charge of Graduate Programs in Art Education*
268 Chambers Building
814-865-5601

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Beittel, Bradley, Hoffa, Schwartz, Van Dommelen, and Wilson.

Graduate Faculty: Associate Members Anderson, Chomicky, and Ott.

This program prepares students for careers in public school art teaching, art supervision, college teaching, administration, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include work in art studio, art history, art education, education, educational psychology, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctoral degree. A foreign language is not required of all Ph.D. degree candidates. In lieu of a foreign language, students will include a series of research and communications studies pertinent to their interests and to their graduate programs and may include a foreign language approved by the doctoral committee.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Transcripts should indicate high attainment in appropriate academic and creative work, and recommendations should attest to scholarship and ability to work independently. Creative work, as shown by slides and photographs, should show a high level of involvement and sensitivity to aesthetic-forming processes.

Students who seek admission to the graduate program must make formal application to the admissions committee of the art education program.

ART EDUCATION (A ED)

- 404. **METHODS OF GRAPHICS AND ILLUSTRATIONS (3)**
- 414. **ADVANCED CRAFTS FOR TEACHERS (3-6)**
- 415. **FIBER CRAFTS IN EDUCATION (3)**
- 417. **METAL CRAFTS IN EDUCATION (3)**
- 420. **CERAMICS FOR TEACHERS (3)**
- 434. **ART APPRECIATION IN THE EDUCATIONAL PROGRAM (3)**
- 435. **ART IN THE ELEMENTARY SCHOOL (3)**
- 436. **ART IN THE SECONDARY SCHOOL (3)**
- 437. **PROFESSIONAL TERM IN ART EDUCATION (10)**
- 486. **CURRENT PROBLEMS IN ART EDUCATION (2-3)**
- 487. **MURAL PAINTING IN SCHOOLS (3)**
- 488. **ADVANCED MURAL PAINTING IN SCHOOLS (3)**

- 489. ART EXPERIENCES WITH CHILDREN (3)
- 490. INTRODUCTION TO RESEARCH IN ART EDUCATION (3)
- 494. SCHOOLS AND MUSEUMS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. SEMINAR IN ART EDUCATION (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.
- 504. ADVANCED METHOD IN GRAPHIC PROCESSES (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.
- 514. FUNCTIONAL RELATIONSHIPS IN CRAFTS (3) Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisite: 6 credits in crafts, or 3 in design and 3 in advanced crafts.
- 516. ANALYSIS OF THREE-DIMENSIONAL PROCESSES IN ART (3) Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.
- 520. ADVANCED CERAMIC ART (3) Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A.Ed. 420.
- 535. ADMINISTRATION AND SUPERVISION OF ART EDUCATION PROGRAMS (3) The problems and responsibilities of the city, county, and state art supervisor; curriculum, facilities, financing, supervision, in-service training, and reporting. Prerequisites: A.Ed. 435, 436.
- 536. CURRICULUM DEVELOPMENT IN ART EDUCATION (3) Factors affecting art curriculum decisions, analysis, selection, organization, preparation of curriculum. Evaluation and sources of art curriculum improvement and innovation. Prerequisite: 6 credits of methods.
- 541. THEORIES OF CHILD ART (3) Study of current theories of child art; application of recent psychological and anthropological theories to understanding child art. Prerequisite: A.Ed. 486 or 501.
- 545. EVALUATION AND ASSESSMENT IN ART EDUCATION (3) Study of theories of evaluation; application of judgmental criteria; analysis and construction of assessment instruments and scoring procedures. Prerequisites: A.Ed. 490, 501.
- 588. HISTORY OF ART EDUCATION (3) Historical development of philosophies in art education in the United States and abroad.
- 589. RESEARCH METHODS IN ART EDUCATION (3-6) Orientation in research methods; findings and designs related to the study of problems in art education.
- 595. RESEARCH IN ART EDUCATION (1-6) Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisite: 15 credits in art education at the 400 and 500 levels, including A.Ed. 589.
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

ART HISTORY (ART H)

HELLMUT W. HAGER, *Head of the Department*
 229 Arts II Building
 814-865-6326

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Battisti, Chenault Porter, Cutler, Fleischer, Hager, Henisch, Kiang, and Maurer.

Graduate work is offered in the following areas: ancient art, medieval and Byzantine art, Renaissance and baroque art, and modern art. Special research opportunities are available through the Center for the Study of Renaissance and Baroque Art.

Candidates for the M.A. degree are required to complete a master's thesis and to demonstrate a reading knowledge of two foreign languages, one of which must be German. The other language is normally French or Italian. Reading knowledge of one of these languages must be demonstrated before the end of four terms of study. These regulations apply equally to Ph.D. students. For those students wishing to enter the doctoral program who have already completed a master's degree from another university, a reading knowledge of one foreign language will be required before the student can be considered for admission to the department.

Candidates with a 3.00 junior-senior grade-point average and a minimum of 21 credits in art history will be considered for admission to the master's program. Lacking these, a promising candidate may be accepted on condition that deficiencies be remedied, but without graduate degree credit. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

ART HISTORY (ART H)

401. STUDIES IN GREEK ART (3)
402. THE ILLUMINATED MANUSCRIPT (3)
404. THE ART OF COLONIAL AMERICA (3)
405. PIONEERS OF MODERN ARCHITECTURE (3-6)
410. TASTE AND CRITICISM IN ART (3)
411. ART OF IMPERIAL ROME (3)
412. THE GOTHIC CATHEDRAL (3)
414. STUDIES IN ITALIAN BAROQUE ART (3-9)
415. THE SKYSCRAPER (3)
416. AMERICAN PAINTING: 1876-1913 (3)
422. STUDIES IN MEDIEVAL SCULPTURE (3)
423. STUDIES IN ITALIAN RENAISSANCE ART (3-9)
424. MASTERS OF NORTHERN BAROQUE ART (3)
425. MOVEMENTS IN NINETEENTH-CENTURY ART (3)
430. GOYA AND HIS TIMES (3)
432. PROBLEMS IN ICONOLOGY (3)
435. MOVEMENTS IN TWENTIETH-CENTURY ART (3-6)
443. PROBLEMS IN BYZANTINE ART (3)
450. THE HISTORY OF PHOTOGRAPHY (3)
451. SURVEY OF SPANISH BAROQUE PAINTING (3)
452. PAINTING IN THE AGE OF LOUIS XIV (3)
456. GIAN LORENZO BERNINI AND THE ARCHITECTURE OF THE FULL BAROQUE IN ROME (3)
458. ROMAN ROCOCO ARCHITECTURE AND THE DAWN OF NEOCLASSICISM (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

510. STUDIES IN ART HISTORY (3-6 per term) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.
511. SEMINAR IN ANCIENT ART (3-12) Selected topics from the history of Greek and Roman art.
512. SEMINAR IN MEDIEVAL ART (3-12) Original research into problems dealing with the art of the Middle Ages.
513. SEMINAR IN RENAISSANCE ART (3-12) Investigations in the area of Renaissance art, centering around major masters and monuments.
514. SEMINAR IN BAROQUE ART (3-12) Investigations in the area of baroque art, centering around major masters and monuments.
515. SEMINAR IN MODERN ART (3-12) Lectures, readings, reports, and discussions in the field of modern art.
517. SEMINAR IN EIGHTEENTH-CENTURY ART (3-12) Investigation into themes and problems dealing with eighteenth-century art.

- 520. SEMINAR IN SPANISH BAROQUE PAINTING (1-6) Specific problems in the history of seventeenth-century Spanish painting.
- 522. SEMINAR IN BYZANTINE ART (3-12) Specific iconographical and stylistic problems in Byzantine art and its relation to classical antiquity, the medieval West, and Islam.
- 525. SEMINAR IN MODERN ARCHITECTURE (3-12) Investigation into the works and problems of modern architecture as they relate to the culture of our times.
- 542. THE ILLUSTRATION OF THE APOCALYPSE (3- 6) Studies in the illustration of the Apocalypse, iconographical and stylistic, from the early Christian period through Dürer.
- 551. HISTORIOGRAPHY OF ART HISTORY (1-6) The relationship between the definition of, and approach to, art-historical problems from Vasari to the present.
- 552. PROBLEMS IN CONNOISSEURSHIP (3) A study of the problems of authenticating, attributing, and dating paintings and sculpture through internal evidence.
- 555. ART HISTORY FIELD SEMINAR (3-12) Investigations based on the site study of specific art objects, with trips in successive years to different art centers.
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

ASTRONOMY (ASTRO)

SATOSHI MATSUSHIMA, *Head of the Department*
 525 Davey Laboratory
 814-865-0418

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Matsushima, Sampson, Usher, and Weedman.

Graduate Faculty: Associate Members Baan, Panek, Ramsey, and Winkler.

Graduate instruction and research opportunities are available in both theoretical and observational astronomy and astrophysics. Currently active areas of theoretical research include atomic processes and radiative transfer, plasma astrophysics, theory of stellar atmospheres, galactic structure and high energy astrophysics, and relativity and cosmology. Observational areas include spectroscopic, photometric, and radio frequency observations of quasars and galaxies; high resolution spectroscopy and rapid photometry of early- and late-type stars, peculiar stars, variable stars, white dwarfs, and stellar flare phenomena; satellite observations of ultraviolet and X-ray spectra of stars and galactic sources; and electronic and computer instrumentation.

The center of observational research facilities is the Penn State Black Moshannon Observatory, located 25 miles northwest of the University Park Campus. Basic instruments are telescopes of 1.6m and 0.6m aperture and a variety of spectrographs and photometers equipped with modern detectors and data acquisition systems. Supplementing the local facilities, national facilities such as Kitt Peak, Cerro Tololo, Sacramento Peak, and Hale, Arecibo, and National Radio Astronomy observatories, as well as satellite observatories are used by Penn State faculty and graduate students.

Modern astronomy has very close ties with mathematics, physics, and engineering. The program required of a doctoral candidate normally includes some courses in these related fields, in addition to those in astronomy. Proficiency in French, German, or Russian is required. A knowledge of computer programming may be substituted for this foreign language requirement. A nonthesis option is available for the M.S. degree.

Applicants with a bachelor's degree in astronomy or an allied field such as physics, mathematics, or geophysics are given equal consideration for admission. Opportunity to make up possible undergraduate deficiencies is provided. A grade-point average of 3.00 or better for junior-senior courses in astronomy and related subjects is necessary for consideration for admission, although exceptions to this minimum requirement may be made for students with special backgrounds, abilities, and interests.

ASTRONOMY (ASTRO)

430. GENERAL ASTRONOMY FOR TEACHERS (3)
460. FUNDAMENTALS OF CELESTIAL MECHANICS (3)
470. SOLAR PHYSICS (3)
480. NEBULAE, GALAXIES, AND COSMOLOGY (3)
490. INTRODUCTION TO ASTROPHYSICS (3)
492. (E.E. 492) SPACE ASTRONOMY AND INTRODUCTION TO SPACE SCIENCE (3)
495. PRACTICAL ASTRONOMY (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
510. ASTROPHYSICS I (3) The theory of atomic structure and spectra and the theory of equilibrium statistical mechanics with applications to astrophysical plasmas. Prerequisite: Astro. 410.
511. ASTROPHYSICS II (3) The theory of atomic processes and radiative transfer with and without the assumption of local thermodynamic equilibrium. Applications to astrophysics.
513. OBSERVATIONAL TECHNIQUES IN ASTRONOMY (3) Theoretical and practical aspects of modern observational astrophysics. Photometry, spectroscopy, stellar classification, detectors, space astronomy and basic information theory. Prerequisite: Astro. 490.
514. OBSERVATIONAL PRACTICE (1-3) Practical experience with the observational research facilities, and with techniques of data acquisition and reduction.
524. CELESTIAL MECHANICS AND SPHERICAL ASTRONOMY (3) Two-body and one-body theory, elliptic motion, expansions, two-body orbit in space, coordinate transformations, planetary equations. Lagrange and Hamilton mechanics. Prerequisite: Astro. 460.
530. THEORY OF STELLAR ATMOSPHERES (3) Theory of photospheric structure, radiative processes, and line-formation in the outer layers of stars, and interpretation of stellar spectra. Prerequisite: Astro. 510.
531. THEORY AND ANALYSIS OF SPECTRAL LINES (3) The formation of spectral lines for both the LTE and NLTE cases, analysis of both line profiles and integrated intensities. Prerequisite: Astro. 530.
534. STELLAR STRUCTURE AND EVOLUTION (3) Theory of physical processes, structure, and evolutionary changes of stars; nature of intrinsic variable stars; the Hertzsprung-Russell diagram. Prerequisite: Astro. 510 or Phys. 561.
542. GASEOUS NEBULAE AND INTERSTELLAR MATTER (3) Theory and observations of galactic nebulae and interstellar medium, and problems related to the formation of stars. Prerequisite: Astro. 510.
582. RADIO ASTRONOMY (3) Methods of radio astronomy and its contribution to modern astrophysics. Galactic and extragalactic sources, using line, continuum, and interferometric observations. Prerequisite: Astro. 490.
583. GALAXIES, QUASARS, AND COSMOLOGY (3) Structure and population of the Milky Way galaxy, properties of galaxies, properties and nature of quasars, distance scale and deceleration parameter. Prerequisite: Astro. 582.
590. COLLOQUIUM (1-3) Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

BIOCHEMISTRY (BIOCH)

M. FRANK MALLETTE, *In Charge of Graduate Programs in Biochemistry*
206 Althouse Laboratory
814-865-1227

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aronson, Bernlohr, Deering, Hammerstedt, Hymer, Karakawa, Mallette, McCarl, Pazur, Phillips, R. Schraer, Shigley, and Wedler.

Graduate Faculty: Associate Member Johnson.

Opportunities for research and graduate study are available in intermediary metabolism, cellular control mechanisms, molecular genetics, enzyme structure, enzyme kinetics and mechanisms, proteins, carbohydrates, lipids, endocrinology, subcellular structures, computer applications, biochemistry of reproduction, heart cell culture, and immunochemistry.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of one foreign language which is widely used by biochemists.

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are not required for admission.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOCHEMISTRY (BIOCH)

- 401. GENERAL BIOCHEMISTRY (3)
- 402. GENERAL BIOCHEMISTRY (3)
- 403. EXPERIMENTAL BIOCHEMISTRY (3)
- 417. BIOCHEMICAL METHODS (4)
- 425. INTRODUCTORY PHYSICAL BIOCHEMISTRY (4)
- 437. PHYSIOLOGICAL BIOCHEMISTRY (3)
- 438. PHYSIOLOGICAL METHODS (2)
- 451. SENIOR SEMINAR (1)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

503. BIOCHEMICAL PROBLEMS (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor.

507. SEMINAR IN BIOCHEMISTRY (1 per term)

514. (Bphys. 514) MOLECULAR BIOLOGY AND CELLULAR REGULATION (3) Structure, synthesis, and biochemical properties of nucleic acids; protein biosynthesis; control of gene expression; molecular genetics. Prerequisite: Bioch. 402.

520. CARBOHYDRATES, LIPIDS, AND THEIR INTEGRATED METABOLISM (3) Chemistry of carbohydrates, lipids, and membranes; interrelationships between lipid and carbohydrate biosynthesis and metabolism. Prerequisite: Bioch. 402.

525. PROTEINS AND ENZYMES (3) Properties of proteins and polypeptides, structural analysis and molecular interactions; enzyme structure, kinetic mechanisms, and control. Prerequisite: Bioch. 402.

590. COLLOQUIUM (1-3)

597. SPECIAL TOPICS (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

BIOENGINEERING (BIOE)

D. B. GESELOWITZ, *Chairman of the Program Committee in Bioengineering*
254 Hammond Building
814-865-1407

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Adams, Anthony, Brickman, Buskirk, Fonash, Geselowitz, Hollis, Jacobs, Kenney, Kline, Michael, Morrow, Munger, Park, Phillips, Pierce, Sharma, Ultman, Weidner, and Zelis.

Graduate Faculty: Associate Members Liedtke, Nellis, and Shung.

This intercollege program is designed to provide the student with graduate-level training in engineering and in the life sciences, and specialized training in specific areas of interaction of engineering with biology and medicine. Graduate instruction in bioengineering is under the direction of a program committee composed of graduate faculty representing several departments.

Opportunities for specialized research include electrical and mechanical properties of biological materials, development of an artificial heart, hemodynamics, electrocardiography, applications to nuclear medicine and radiology, biomaterials, lung mechanics, bioinstrumentation, transducers, rheology of biological fluids, and ultrasonics.

The particular course of study depends on the student's background and area of research specialization. Courses are selected from the life sciences, engineering, and bioengineering. Candidates for the Ph.D. degree generally are expected to complete Phsio. (Biol.) 571-573 plus several additional courses in the life sciences, five courses in bioengineering, and five graduate-level courses in engineering, mathematics, and physics. Supporting courses are available at University Park and The Milton S. Hershey Medical Center in acoustics, anatomy, biochemistry, biology, biophysics, chemistry, laboratory animal medicine, materials science, mathematics, physiology, polymer science, psychology, and the engineering departments.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by demonstrating intermediate knowledge of an acceptable foreign language, or by taking an advanced technical writing course and presenting a formal proposal for thesis research to the doctoral committee.

A thesis is required for the M.S. degree. Course requirements include Bioe. 401 and 402 plus two 500-level courses in bioengineering, 6 credits in the life sciences including Biol. 472, and 6 credits in technically oriented courses outside of bioengineering and the life sciences. In addition, students without a previous degree in engineering or physics are required to complete up to 24 additional credits in engineering. Most of this additional course work will be at the undergraduate level, and typically includes statics and dynamics, electric circuits and linear fields, electronic devices, fluids mechanics, and linear systems.

Students with a degree in engineering, physics, or the life sciences will be eligible for admission. All students must have a strong background in physics and mathematics. This background should include 9 credits in chemistry, 9 credits in physics and mathematics through calculus and differential equations and a course in linear systems analysis. Students who lack one or two courses may still be considered for admission but will have to make up any deficiency early in their graduate program. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOENGINEERING (BIOE)

401. INTRODUCTION TO BIOENGINEERING (3)

402. BIOMEDICAL INSTRUMENTATION AND MEASUREMENTS (3)

- 425. (Nuc.E. 425) RADIOGRAPHIC IMAGING (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. BIOENGINEERING TRANSPORT PHENOMENA (3) Application of the equations of mass, energy, and momentum conservation to physiological phenomena and to the design of artificial organs.
- 502. INTRODUCTION TO BIOELECTRIC PHENOMENA (3) Electric phenomena in nerve and muscle, membrane potentials, Hodgkin-Huxley equations, volume conductor problem, applications to electrocardiography, electroencephalography, plethysmography.
- 503. FLUID MECHANICS OF BIOENGINEERING SYSTEMS (3) Cardiovascular system and blood flow, non-newtonian fluid description, vessel flows, unsteady flows and wave motion, windkessel theory, transmission line theory.
- 504. PHYSIOLOGICAL SYSTEMS ANALYSIS (3) Application of systems theory, control theory, and analytic modeling strategies to the study of physiological systems. Prerequisites: Biol. 472, Engr. 100.
- 505. BIOENGINEERING MECHANICS (3) Passive and active mechanical properties of tissues, rheological materials, models of muscle contraction, pulmonary mechanics, forces in muscular-skeletal system.
- 570. TOPICS IN BIOMEDICAL INSTRUMENTATION (1) Physiological basis, theory of operation, and practical aspects of clinical instrumentation.
- 580. BIOENGINEERING INTERNSHIP (3-6) Supervised experience at The Milton S. Hershey Medical Center including rotation through services and work on a minor project. Prerequisites: Bioe. 402 and 3 credits in bioengineering at the 500 level.
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

BIOLOGICAL CHEMISTRY (BCHEM)

EUGENE A. DAVIDSON, *Chairman of the Department*
 The Milton S. Hershey Medical Center
 Hershey, PA 17033
 717-534-8585

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Davidson, Hass, Hill, Miljkovic, Schengrund, and Shiman.

Graduate Faculty: Associate Members Bhavanandan, A. Hopper, J. Hopper, and Rose.

Opportunities for research and graduate study are available in the chemistry and metabolism of complex polysaccharides, cellular differentiation, mechanism of enzymatic reactions, biochemical genetics, biochemistry of complex lipids, conformational analysis of carbohydrates and proteins, natural product chemistry, and physical chemistry of macromolecules.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. The nonthesis option is available for the M.S. degree.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Interested students should contact the department chairman.

The program is offered only at The Milton S. Hershey Medical Center.

BIOLOGICAL CHEMISTRY (BCHEM)

502. **BIOLOGICAL CHEMISTRY I (3)** Structure-function relationships of macromolecules; pathways utilized for energy generation in mammalian systems; concepts of metabolic regulation. Concurrent: Micrb. 556.

503. **NUCLEIC ACID BIOCHEMISTRY (2)** Aspects of the mechanism and control of nucleic acid and protein biosynthesis with emphasis on their relationship to genetic phenomena. Prerequisite: Micrb. 556.

504. **BIOLOGICAL CHEMISTRY LABORATORY (2)** Laboratory exercises in biological chemistry related primarily to mammalian systems. Experience with a range of contemporary techniques. Prerequisite or concurrent: B.Chem. 502.

505. **BIOLOGICAL CHEMISTRY II (3)** A continuation of B.Chem. 502. Emphasis on interrelations of metabolic pathways, catabolic end products, and regulation. Prerequisites: B.Chem. 502; Micrb. 556.

513. **BIOLOGICAL CHEMISTRY, MACROMOLECULES (3)** Physical chemistry of macromolecules; techniques for investigating conformations, size, and interactions. Development and application of thermodynamics to solutions of macromolecules.

523. **METABOLISM (3)** Molecular mechanisms employed by living systems to transform biological compounds, control production and utilization of energy, and regulate metabolic pathways.

551. **KINETICS AND MECHANISM OF ENZYME ACTION (3)** Current kinetic theory, rapid reactions, regulatory enzymes, chemical and physical approaches to the study of the mechanism of enzyme action. Prerequisite: B.Chem. 502. Concurrent: B.Chem. 523.

553. **BIOCHEMICAL TECHNIQUES (3)** Lectures and discussion on approaches to macromolecule and lipid separation and characterization; isolation of subcellular organelles; enzymatic assay; radioisotopes. Prerequisite: B.Chem. 502.

590. **COLLOQUIUM (1-3)**

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

BIOLOGY (BIOL)

E. S. LINDSTROM, *Head of the Department*
208 Erwin W. Mueller Building
814-865-4562

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthony, Bellis, Cooper, Dunson, Fergus, Graves, Grun, Hamilton, Hibbard, Hillson, Hollis, Keener, MacCluer, Pursell, Schein, Spackman, Therrien, Traverse, Wickersham, Williams, and Wright.

Graduate Faculty: Associate Members Burris, Mitchell, Neff, Pearson, Petters, Rheuben, Stephenson, and Turpen.

The department will direct graduate programs in behavior, cell biology, cytology, cytochemistry, environmental science, ultrastructure, and other aspects of modern biology. The courses of study are planned individually by the student and an adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. Candidates have the option of a thesis or a paper for the M.S. degree.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide scores from the Graduate Record Examination, a personal statement of interests and objectives, and letters from two persons verifying the applicant's academic competence.

BIOLOGY (BIOL)

402. VERTEBRATE NEUROANATOMY (3)
407. PLANT ANATOMY (3)
409. BIOLOGY OF AGING (3)
414. ADVANCED SYSTEMATIC BOTANY (3)
417. INVERTEBRATE ZOOLOGY (4)
418. MYCOLOGY (3)
420. (Geosc. 420) PALEOBOTANY (3)
421. COMPARATIVE ANATOMY OF VERTEBRATES (4)
422. ADVANCED GENETICS (3)
423. (Geosc. 423) INTRODUCTORY PALYNOLOGY (3)
426. INTRODUCTORY CYTOGENETICS (3)
427. (Geosc. 427) EVOLUTION (3)
428. POPULATION GENETICS (3)
429. DEVELOPMENTAL GENETICS (3)
431. COMPARATIVE PLANT MORPHOLOGY (2)
432. LABORATORY IN COMPARATIVE PLANT MORPHOLOGY (2)
433. TERRESTRIAL ECOLOGY (3)
434. TERRESTRIAL ECOLOGY LABORATORY (2)
435. ECOLOGY OF LAKES AND STREAMS (3)
436. FRESHWATER ECOLOGY RESEARCH TECHNIQUES (3)
437. HISTOLOGY (4)
438. ORNITHOLOGY (2)
439. ORNITHOLOGY LABORATORY (2)
440. EMBRYOLOGY (4)
441. PLANT PHYSIOLOGY (3)
442. PLANT PHYSIOLOGY (3)
445. PHYTOHORMONES (3)
446. PHYSIOLOGICAL PLANT ECOLOGY (2)
452. ICHTHYOLOGY (3)
454. HERPETOLOGY (2)
460. EMBRYONIC DIFFERENTIATION (3)
464. (An.Sc. 464) ANIMAL BEHAVIOR — SOCIOLOGY (3)
465. GENERAL CYTOLOGY (3)
466. LABORATORY IN CYTOLOGY (1)
467. CYTOCHEMICAL METHODS (3)
472. VERTEBRATE PHYSIOLOGY (3)
473. LABORATORY IN VERTEBRATE PHYSIOLOGY (2)
477. BIOLOGY OF HUMAN SEXUALITY (3)
478. BIOLOGICAL AND MEDICAL ASPECTS OF THE MAMMARY GLAND (2)
479. GENERAL ENDOCRINOLOGY (3)
482. COASTAL BIOLOGY (4)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

502. THE PHYSIOLOGY OF THE FUNGI (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years.

504. (Bphys. 504) SEMINAR IN CELL BIOLOGY (1) Discussion of current problems and ideas in cell biology with emphasis on reference to recent literature.

506. COMPARATIVE ANATOMY OF VASCULAR PLANTS (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Biol. 407. Spring term, even years.

511. ADVANCED PLANT PHYSIOLOGY (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration and catabolism. Prerequisite: Biol. 442. Fall term.

512. **ADVANCED PLANT PHYSIOLOGY (3)** Continuation of Biol. 511. Physiology of plants including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: Biol. 442. Winter term.
516. **ECOLOGICAL PLANT GEOGRAPHY (3)** Distribution of plant communities; environmental factors which influence their present distribution; geological-historical development of plant communities, their past distribution. Winter term, odd years.
517. **FISH BEHAVIOR AS RELATED TO AQUATIC ECOLOGY (3)** Receptor-effector systems, selection of habitat and the effects of behavioral interaction on population levels, growth and survival. Prerequisite: Biol. 452 or 462.
518. **SPECIAL PROBLEMS (1-6)** Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.
519. **ZOOGEOGRAPHY (3)** The present distribution of world vertebrates, their evolution, and their patterns of dispersal in the past.
522. **LOWER FUNGI (3)** Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Biol. 418. Winter term, even years.
523. **HIGHER FUNGI (3)** Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Biol. 418. Spring term, even years.
524. **SEMINAR IN GENETICS (1 per term)**
526. (Geol. 526) **PROBLEMS IN PALYNOLOGY (1-6)** Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history.
531. **BRYOLOGY (3)** Morphology, taxonomy, and ecology of liverworts, hornworts, and mosses; collection, preservation, culturing, and cytologic techniques. Spring term, even years.
533. **PROBLEMS IN GENETICS (2-6)** Problems to suit needs of individual students; conferences and laboratory work.
535. **MORPHOLOGY OF THE TRACHEOPHYTES EXCLUSIVE OF ANGIOSPERMS (3)** Origin, developmental tendencies, structure, and paleobotanical evidence. Winter term, odd years.
536. **MORPHOLOGY OF ANGIOSPERMS (3)** Floral origin and development, fertilization, embryogeny, seeds and fruit development. Prerequisite: Biol. 431.
538. **PRINCIPLES OF MICROSCOPIC HISTOCHEMISTRY (2)** Theoretical basis for the microscopic identification, localization, and quantitative analysis of chemical substances in tissues of organisms. Prerequisite: Biol. 437 or 465.
539. **ANALYTICAL HISTOCHEMISTRY LABORATORY (2-4)** Application of histochemical techniques in the microscopic analysis of tissue lipids, proteins, carbohydrates, nucleic acids and proteins. Prerequisite or concurrent: Biol. 538.
540. **PHYCOLOGY (4)** Comparative morphology, taxonomy, and ecology of freshwater and marine algae; culturing, collection, preservation techniques.
542. (Ent. 542) **SYSTEMATICS (3)** Principles and methods of classification, phylogeny and speciation; taxonomic techniques, analysis of species; causal interpretation of animal diversity.
544. **PHYSIOLOGICAL ECOLOGY (3)** The physiological abilities of animals to tolerate and compensate for changes in the physical and chemical nature of the environment.
545. **ECOSYSTEM DYNAMICS (3)** Survey and discussion of recent literature on ecosystem structure and function. Prerequisite: Biol. 210.
546. **ECOLOGY OF POPULATION AND COMMUNITIES (3)** Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term.
547. **INVERTEBRATE BIOLOGY (3)** Embryological development, metamorphosis, regeneration, and endocrinology of selected invertebrate groups (insects excluded). Invertebrate interactions and ecological impact.

550. NEUROGENESIS (2) Embryonic and evolutionary development of the nervous system. Determination, differentiation, orientation, and specificity of growing and regenerating nerve cells. Prerequisite: Biol. 440.
557. (Sci.Ed. 557) WORKSHOPS IN THE BIOLOGICAL SCIENCES (3) Projects designed for teachers of biology in the secondary schools. Summer term only.
571. (Phsio. 571) ANIMAL PHYSIOLOGY (2) Mammalian cardiovascular system; mammalian neurophysiology; excitable tissue, sensory systems, motor systems, and autonomic system. Prerequisite: Biol. 472.
572. (Phsio. 572) ANIMAL PHYSIOLOGY (2) Mechanisms involved in the activity and control of gastrointestinal function, respiration, and renal regulation of blood and body fluids. Prerequisite: Biol. 472.
573. (Phsio. 573) ANIMAL PHYSIOLOGY (2) Hypothalamic-hypophyseal relationships. Reproductive cycle regulation, endocrine control of fluid balance, body temperature, energy homeostasis, and metabolism of protein and minerals. Prerequisite: Biol. 472.
582. (Pty.Sc. 582, Psy. 582) RESEARCH IN ANIMAL BEHAVIOR (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.
585. (Bphys. 585) BIOLOGICAL ULTRASTRUCTURE (4) The application of electron microscopy to the study of cell biology. Prerequisite: Bphys. 473 or Biol. 437 or 465 or Micrb. 401.

BIOPHYSICS (BPHYS)

REGINALD A. DEERING, *In Charge of Graduate Programs in Biophysics*
618 Erwin W. Mueller Building
814-865-0342

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Deering, Keith, Morgan, Person, H. Schraer, Smyth, Snipes, Strother, Taylor, and Todd.

The major goal of this program is to train students for independent research and teaching in the interdisciplinary areas of biophysics and molecular biology. The students currently in the department have come from a variety of fields including physics, engineering, chemistry, biochemistry, and biology. Graduate students are expected to begin a research program during their first year of study. Personal attention is given by a faculty adviser to insure that the program is suited to the student's talents and is one that will permit the earning of a degree in a reasonable time. Course requirements are flexible and depend to a considerable extent on the student's research interests. The master's program is expected to take from six to eight terms (four terms per year), and the Ph.D. usually requires an additional eight to twelve terms, including thesis research. Advancement to Ph.D. candidacy is decided on the basis of course and research performance in addition to a written examination. A comprehensive oral examination and thesis defense are integral parts of the Ph.D. program. Knowledge of a foreign language may be required depending on the area of research.

Research interests include radiation biology and DNA repair, cell biology, molecular biology and genetics, electrophysiology, structure and function of biological membranes, molecular virology, developmental biology, biophysical chemistry, cytofluorometry, electron microscopy, and chemical carcinogenesis.

BIOPHYSICS (BPHYS)

415. STRUCTURE OF BIOLOGICAL MACROMOLECULES (2)
430. MOLECULAR BIOLOGY OF THE GENE (3)
440. STRUCTURE AND FUNCTION OF BIOLOGICAL MEMBRANES (3)

473. MOLECULAR BIOPHYSICS I (3)
 474. MOLECULAR BIOPHYSICS II (3)
 475. INTRODUCTORY RADIATION BIOPHYSICS (3)
 476. NEUROPHYSIOLOGY (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
503. BIOPHYSICS OF MEMORY (2) Molecular biology, pharmacology and physiology of learning, memory formation and recall. Reading and discussion of the pertinent current literature. Prerequisite: Bioch. 401 or Bphys. 475.
504. (Biol. 504) SEMINAR IN CELL BIOLOGY (1) Discussion of current problems and ideas in cell biology with emphasis on reference to recent literature.
514. MOLECULAR BIOLOGY AND CELLULAR REGULATION (3) Structure, synthesis, and biochemical properties of nucleic acids; protein biosynthesis; control of gene expression; molecular genetics. Prerequisite: Bioch. 402.
585. (Biol. 585) BIOLOGICAL ULTRASTRUCTURE (4) The application of electron microscopy to the study of cell biology. Prerequisite: Bphys. 473 or Biol. 437 or 465 or Micrb. 401.
587. ULTRACENTRIFUGATION (2) A laboratory course in ultracentrifugation techniques including applications to biophysical problems. Prerequisite: Bphys. 474.
588. PHYSIOLOGY OF NERVES, MUSCLES, AND SENSE ORGANS (2-6) Current literature of the function of nerves, muscles, and receptors. These subjects are considered individually in successive years. Prerequisite: a 400-level course in physiology, biophysics, or physiological psychology.
589. MAMMALIAN CELL CULTURE (3) Recent research in quantitative cell biology as studied with tissues and cells of higher organisms cultured *in vitro*. Prerequisite: Bioch. 401.
590. COLLOQUIUM (1-3)
595. ELECTRON SPIN RESONANCE SPECTROSCOPY (3) Experimental and theoretical aspects of electron spin resonance spectroscopy to provide ability for its application to biophysical problems. Prerequisite: basic knowledge of quantum mechanics and electromagnetic waves.
597. SPECIAL TOPICS (1-6)

BOTANY (BOT)

E. S. LINDSTROM, *Head of the Department of Biology*
 208 Erwin W. Mueller Building
 814-865-4562

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Fergus, Grun, Hamilton, Hillson, Keener, Pursell, Schein, Spackman, Therrien, Traverse, and Wright.

Botanical programs are offered in plant anatomy, bryology, cytology, ecology, genetics, morphology, mycology, paleobotany, palynology, physiology, and taxonomy. A student having a degree in science or in one of the biological sciences is eligible for admission. Entering graduate students should have had basic courses in chemistry, mathematics, and physics. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide scores from the Graduate Record Examination, a personal statement of interests and objectives, and letters from two persons verifying the applicant's academic competence.

See also Genetics and Physiology.

NOTE: For courses in Botany and related subjects see *Biology*.

BUSINESS ADMINISTRATION (B A)

MICHAEL P. HOTTENSTEIN, *Director of the M.B.A. Program*
JOHN D. DANIELS, *Director of the M.S. and Ph.D. Programs*
101 Business Administration Building
814-863-0474

Degrees Conferred: Ph.D., M.S., M.B.A.

Graduate Faculty: Senior Members Aggarwal, Bear, Beik, Bennett, Bither, Bradley, Carróll, Coyle, Curley, Daniels, Dinkel, Dirsmith, Durkin, Ezzell, Ferrara, Greenlaw, Hammond, Hayya, Heitmann, Henszey, Hottenstein, Jablonsky, Kelley, Kleindorfer, Kochenberger, Koot, Malcom, Olson, Pashek, Philippatos, Philips, Radebaugh, Richards, Rigby, Schrader, Shapiro, Sheridan, Shilling, Sims, Spychalski, Susman, Thies, and D. Wilson.

Graduate Faculty: Associate Members Bluedorn, Cavinato, Chatterjee, Davis, Gouldley, Holman, Koehler, Lusht, Luzi, Marlow, McCormack, Melander, Miller, Millman, Myers, Nelson, Phalan, Pitts, Raju, Rao, Reeder, Reutzel, Snow, Stenger, Teichman, Tretter, Twark, Tyworth, Watson, Williams, R. Wilson, Wood, and Woolridge.

The Master of Business Administration is a professional degree program in business administration designed to prepare individuals for managerial positions in business, as well as government and other nonprofit institutions. Individuals of all undergraduate disciplines, both business and nonbusiness, are encouraged to apply. This program consists of two distinct portions: (1) 3 credits each in undergraduate accounting, statistics, and economics (not exclusively macroeconomics). These prerequisite courses may be taken as part of an undergraduate curriculum or at the University prior to starting graduate-level studies; (2) 48 credits of graduate courses and a professional paper.

Graduate-level work on the M.B.A. degree may be started fall term only. The time required to complete the graduate program, based on full-time study, is fifteen months. The student body is divided into diverse sections of approximately forty students, with each section proceeding through the same core classes. Emphasis is placed on student interaction and shared learning both inside and outside the classroom.

The M.S. and Ph.D. programs with a major in business administration are designed for those interested primarily in research and teaching. The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of two foreign languages or a reading, listening, and speaking knowledge of one language. The candidate may substitute quantitative analysis and/or behavioral science for the required reading knowledge in one or two languages. A student has an option of a thesis or a paper for the M.S. degree.

For admission to the M.S. program, approximately 33 acceptable undergraduate credits in business administration, economics, and mathematics are required. An applicant may be admitted without foundation courses, but they must be made up without degree credit. Applicants are evaluated for admission on the basis of academic potential and other factors giving evidence of high probability of completing the program. Data useful for evaluating academic potential include the applicant's professional and academic accomplishments, the Graduate Management Admission Test (GMAT) scores, and recommendations. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Applicants to any of the graduate programs in business administration are required to take the Graduate Management Admission Test (GMAT) which is administered by the Educational Testing Service four times a year. For dates, locations, and any other information on the test, write for the *Bulletin of Information*, Graduate Management Admission Test, Educational Testing Service, Princeton, New Jersey 08540.

This graduate program is accredited by the American Association of Collegiate Schools of Business.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 239).

ACCOUNTING (ACCTG)

- 401. ADVANCED ACCOUNTING (3)
 - 403. AUDITING (3)
 - 404. MANAGERIAL ACCOUNTING (3)
 - 406. ADVANCED FEDERAL TAXATION (3)
 - 409. ACCOUNTING INFORMATION SYSTEMS (3)
 - 413. AUDITING INTERNSHIP (3)
 - 414. MANAGERIAL ACCOUNTING INTERNSHIP (3)
 - 421. INTERNATIONAL ACCOUNTING (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
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- 501. RESEARCH METHODS IN ACCOUNTING (3) An introduction to the methods and techniques of contemporary research in accounting. Prerequisites: Acctg. 504, 507, and a course in statistical inference.
 - 503. SEMINAR IN AUDITING (3) The attest function of independent public accountants, verification of financial statements; problems of evidence, independence, ethics, professional responsibilities. Prerequisite: Acctg. 403.
 - 504. SEMINAR IN MANAGERIAL ACCOUNTING (3-6) Accounting and the managerial processes of planning, control, and decision making.
 - 507. SEMINAR IN FINANCIAL ACCOUNTING (3) Theoretical basis of financial accounting.
 - 508. CONTEMPORARY ISSUES IN ACCOUNTING (3) Selected problems of current interest to the accounting profession.
 - 511. FINANCIAL AND MANAGERIAL ACCOUNTING (3) Fundamental financial and managerial accounting concepts and issues from the viewpoint of the report user.
 - 512. FINANCIAL ACCOUNTING THEORY AND REPORTING PROBLEMS (3) Measurement and reporting of financial information for external purposes, with particular attention to current problems in asset and income measurement. Prerequisite: Acctg. 511.
 - 514. SEMINAR IN FEDERAL TAXATION (3) The federal tax structure, including legal, economic, and government implications; focusing on business decisions, research methodology, and tax planning.
 - 515. DEVELOPMENT OF ACCOUNTING THOUGHT (3) Development of accounting thought from ancient civilizations to the present.
 - 516. SEMINAR IN NOT-FOR-PROFIT ACCOUNTING (3) Measurement and structuring of financial information for managerial planning and control and external reporting.
 - 590. COLLOQUIUM (1-3)
 - 596. INDIVIDUAL STUDIES (1-6)
 - 597. SPECIAL TOPICS (1-6)
 - 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2)

BUSINESS ADMINISTRATION (B A)

- 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
 - 499. FOREIGN STUDY IN BUSINESS ADMINISTRATION (2-6)
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- 503. SEMINAR IN PUBLIC UTILITIES (3)
 - 517. COMMUNICATION SKILLS FOR MANAGEMENT (1 per term, maximum of 3) Development of communication skills required for management; audience awareness, style, individual and group presentations. Prerequisite: admission to the Master of Business Administration Program.

537. (Cmp.Sc. 537) **MANAGEMENT INFORMATION SYSTEMS DESIGN (3)** Cost, value, and technical considerations in analysis and design of information systems whose purposes are to aid decision making in organizations.
538. **INFORMATION SYSTEMS FOR PLANNING AND CONTROL (3)** Analysis of information requirements for planning, decision making, and performance measurement in organizations.
539. **SEMINAR IN MANAGEMENT INFORMATION SYSTEMS (3)** Special topics selected from contemporary issues in management information systems.
550. **BEHAVIORAL SCIENCE IN BUSINESS (3)** Application of behavioral science concepts and analytical methods to problems in business organizations. Analysis of administrative behavior and decision making.
555. **BUSINESS AND SOCIETY (3)** Evolution of the business organization and the changing framework of its operations, responsibilities, and social control.
560. **ENTERPRISE CONSULTING (3)** Student groups engaging in consulting relationships with enterprises through use of managerial techniques for identification, analysis, and solution of managerial problems. Prerequisites: Acctg. 511; B.A. 550, 555; Econ. 500; Q.B.A. 510 and 521.
574. **BUSINESS RESEARCH (1-3)** A project paper, comparable in quality and scope of work to a graduate thesis, on problems of a company. Prerequisite: 15 credits of 400- and 500-level courses in business administration.
577. **ADMINISTRATIVE INTEGRATION (3)** An analysis of coordination of the functional areas of business in relation to overall company objectives. Prerequisite: 15 credits of 400- and 500-level courses in business administration.
578. **ENTREPRENEURSHIP (3)** Study of the development or acquisition of a business appropriate to the objectives and resources of the individual entrepreneur.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

BUSINESS LAW (B LAW)

400. **REAL ESTATE LAW (3)**
410. **CRIMINAL LAW AND PROCEDURES IN THE BUSINESS COMMUNITY (3)**
496. **INDEPENDENT STUDIES (1-12)**
497. **SPECIAL TOPICS (1-6)**

BUSINESS LOGISTICS (B LOG)

412. **TRANSPORT PLANNING ANALYSIS (3)**
420. **URBAN TRANSPORTATION (3)**
430. **TRANSPORT PROBLEMS (3)**
440. **LOGISTICS SYSTEMS ANALYSIS (3)**
496. **INDEPENDENT STUDIES (1-12)**
497. **SPECIAL TOPICS (1-6)**
538. **LOGISTICS SYSTEMS MANAGEMENT (3)** Control of the movement of goods; coordination of supply and demand in creation and maximization of time and place utility.
540. **TRANSPORT POLICY (3)** Role of transport in the economy. Transport systems elements, development, cost and pricing characteristics. Public control and public policies.
541. **SOCIOECONOMIC ANALYSIS IN TRANSPORTATION (3)** Role of transport in social and economic activity. Planning and coordination of transport systems. Designed for the traffic engineering program.
565. **SEMINAR IN BUSINESS LOGISTICS (3-6)**

- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

FINANCE (FIN)

- 405. CAPITAL BUDGETING (3)
- 406. SECURITY ANALYSIS AND PORTFOLIO MANAGEMENT (3)
- 408. FINANCIAL MARKETS (3)
- 410. SPECULATIVE MARKETS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 504. PROBLEMS IN FINANCE (3-6) Planned individual projects involving library, laboratory, or field work.
- 505. (I.B. 505) MULTINATIONAL MANAGERIAL FINANCE (3) Analysis of the international aspects of managerial finance. Emphasis on the environmental and institutional factors influencing capital acquisition and allocation. Prerequisite: Fin. 531.
- 506. PORTFOLIO THEORY AND POLICY (3) Rigorous examination and analysis of asset-holder behavior under conditions of risk and uncertainty.
- 508. ANALYSIS OF FINANCIAL MARKETS (3) Analysis of factors affecting price determination in financial markets.
- 510. CONTEMPORARY ISSUES IN FINANCIAL INSTITUTIONS (3) Critical investigation of problems of current interest in the market structure and internal operations of financial institutions.
- 531. FINANCIAL MANAGEMENT (3) An intensive examination of techniques available to aid the financial manager in decision making.
- 532. FINANCIAL DECISION PROCESSES (3) Financial decision making under uncertainty; positive and normative models and current issues in financial management.
- 541. SECURITY ANALYSIS (3) Discussion and application of analytical techniques in security valuation, including use of computers.
- 561. SEMINAR IN FINANCE (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

INSURANCE (INS)

- 400. ESTATE PLANNING (3)
- 401. FUNDAMENTALS OF PRIVATE PENSIONS (3)
- 410. COMPOUND INTEREST AND ANNUITIES — CERTAIN (3)
- 411. LIFE CONTINGENCIES I (3)
- 412. LIFE CONTINGENCIES II (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 500. INSURANCE THEORY AND PRACTICE (3) Insurance as an institution, a technique, a legal contract; its environment as a regulated industry.
- 504. PROBLEMS IN INSURANCE (3) Planned individual projects involving library, laboratory, or field work.

510. RISK MANAGEMENT (3) Analysis of managerial problems and responsibilities of risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.

596. INDIVIDUAL STUDIES (1-6)

INTERNATIONAL BUSINESS (I B)

501. THE INTERNATIONAL ENVIRONMENT (3) Conceptual approach analyzing and predicting influences of social, political, and economic norms and values upon diverse societies' managerial decision making.

502. INTERNATIONAL BUSINESS MACRO THEORY AND POLICY I (3) International economic trade and monetary tools are applied to current national policy issues to determine effects on international business operations. Prerequisite: Econ. 333.

503. INTERNATIONAL BUSINESS MICRO THEORY AND POLICY I (3) Analysis of the internal operations of multinational firms; design of optimal strategies of operation under varying environmental conditions.

504. SEMINAR IN INTERNATIONAL BUSINESS (3-6) Seminar in techniques applied to selected topics; market structures; capital budgeting, investment; comparisons of foreign norms and values; multinational organization characteristics.

505. (Fin. 505) MULTINATIONAL MANAGERIAL FINANCE (3) Analysis of the international aspects of managerial finance. Emphasis on the environmental and institutional factors influencing capital acquisition and allocation. Prerequisite: Fin. 531.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

MANAGEMENT (MGMT)

410. OPERATIONS PLANNING AND CONTROL (3)

420. MANAGEMENT OF PERSONNEL SYSTEMS (3)

422. ADVANCED ORGANIZATION THEORY (3)

430. ADMINISTRATIVE MANAGEMENT (3)

432. SIMULATION OF MANAGEMENT SYSTEMS (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

510. OPERATIONS MANAGEMENT (3) Integration and application of decision making to operational and policy problems within the business firm.

515. DESIGN OF OPERATION OUTPUT SYSTEMS (3) Examination of research-based findings in operations management with a focus on the design and reliability of production systems.

516. OPERATIONS PLANNING AND CONTROL (3) Examination of research-based findings in operations management. The focus is on the operation and control of production systems.

517. MANAGEMENT OF SOCIO-TECHNICAL SYSTEMS (3) Surveys the economic, psychological, and sociological issues of work quality in terms of managerial implications and change strategies.

518. MANAGEMENT OF INVENTORY SYSTEMS (3) Analysis of business organizations as integrated inventory systems. Inventory theory and model building as tools for management decision making. Prerequisite: Q.B.A. 561 or Mgmt. 510 or I.E. 509.

520. COMPLEX ORGANIZATIONS: STRUCTURE AND DESIGN (3) Analysis of theory, research, and practice in the design of complex organizations. Relationships between organizational environments and structures are emphasized.

- 521. ORGANIZATIONAL POWER AND CONTROL (3) Theoretical and research emphasis on the bases and consequences of power and control in complex organizations.
- 523. ORGANIZATIONAL CHANGE: THEORY AND PRACTICE (3) Analysis of research, theory, and practice in dynamics of organizational change. Research literature reviewed for evaluation of concepts and methods.
- 524. INTERPERSONAL RELATIONS IN ORGANIZATIONS (3) Development of skills and sensitivity for dealing with interpersonal relationships in complex organizations. Prerequisite: B.A. 550.
- 531. MANAGEMENT INFORMATION SYSTEMS (3) Information system theories and methods applied to administrative structures and management decisions in organizations.
- 540. PERSONNEL MANAGEMENT (3) Theory and practice of personnel management and analysis of personnel problems of relevance to all types of managers.
- 570. SEMINAR IN MANAGEMENT (3-6) Comparative analysis of research in the theories of the administrative sciences; relationships to business management practices.
- 575. FUTURE STUDIES AND MANAGERIAL PLANNING (3) Theory and research on the "future" dimensions of decision making and planning, particularly under conditions of rapid change.
- 576. PLANNING MODELS AND TECHNIQUES (3) Survey of models, concepts, and techniques appropriate to managerial long-range planning in complex organizations.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

MARKETING (MKTG)

- 422. SEMINAR: MARKETING COMMUNICATION (3)
- 424. MARKETING RESEARCH PROJECTS (3)
- 430. CONSUMER BEHAVIOR (3)
- 435. MARKETING AND PUBLIC POLICY (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 500. MARKETING MANAGEMENT (3) Analysis of management's marketing problems including market analyses, pricing, channel of distribution, promotion, competition, product strategies, and marketing research.
- 510. PLANNING MARKET STRATEGY AND PROGRAMS (3) Development of marketing strategy for the firm and design of integrated product-service, promotion, and distribution programs utilizing systems analysis.
- 520. QUANTITATIVE ANALYSIS FOR MARKETING DECISIONS (3) Sales forecasting, new product proposals, media selection, and market testing analyzed using statistical and decision theory and other mathematical techniques.
- 530. CONSUMER AND MARKET BEHAVIOR (3) Buying behavior: concepts from the behavioral sciences, including utility, culture, life cycle, personality, attitudes, and learning.
- 540. MARKETING AND SOCIETY (3) Marketing problems of society, domestic and regional marketing systems; governmental policies toward marketing; social performance of marketing.
- 544. MARKETING THEORY (3) The development of marketing concepts, behavioral and other marketing theories; public policy and the role of marketing in societies.
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

QUANTITATIVE BUSINESS ANALYSIS (Q B A)

- 404. SAMPLING IN BUSINESS OPERATIONS AND RESEARCH (3)
- 451. LINEAR PROGRAMMING (3)
- 452. NONLINEAR PROGRAMMING (3)
- 461. PROBABILISTIC MODELS IN BUSINESS (3)
- 490. ADVANCED BUSINESS STATISTICS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

*398G. ACCELERATED BUSINESS STATISTICS (3) Basic characteristics of univariate and bivariate distributions, probability theory, introduction to estimation, tests of hypotheses, and time series analysis. Open to graduate students only.

- 500. SEMINAR IN BUSINESS STATISTICS (3-6)

- 501. ADVANCED BUSINESS STATISTICS (3)

510. STATISTICAL ANALYSIS FOR MANAGERIAL DECISION MAKING (3) Use of statistical methods for managerial decision making with emphasis on problem formulation, data analysis and interpretation, and business applications. Prerequisites: 3 credits each in undergraduate accounting, economics, and statistics.

521. QUANTITATIVE ANALYSIS FOR BUSINESS DECISIONS (3) Construction and use of quantitative methods in business decision making. Prerequisite: common requirements of M.B.A. program.

527. ANALYSIS FOR DECISION MAKING UNDER UNCERTAINTY (3) Topics in decision making under uncertainty including decision theory, Bayesian statistics, payoff function including utility theory and multi-attribute measures.

532. MANAGEMENT SYSTEMS SIMULATION (3) Application of computer simulation to the analysis and design of management decision systems. Design of simulation experiments in business research. Prerequisite: 3 credits of computer programming.

540. MATHEMATICAL PROGRAMMING (3) Nonlinear programming and geometric programming with emphasis on both theory and applications. Prerequisite: Q.B.A. 452.

550. SEMINAR IN MATHEMATICAL PROGRAMMING (3-6) Intensive treatment of theory and computational algorithms of mathematical programming; emphasis on operational application to complex management and business problems. Prerequisite: I.E. 510.

561. STOCHASTIC MODELS FOR MANAGEMENT DECISIONS (3) Introduction to stochastic processes in business organizations. Application of stochastic models to the conceptualization, analysis, and solution of management problems. Prerequisite: Math. (Stat.) 427.

570. MANAGEMENT SCIENCE: IMPLEMENTATION AND CONTROL (3) Development and application of management science models. Model formulation and specification, sensitivity analysis, problems encountered in implementation and control.

- 590. COLLOQUIUM (1-3)

- 596. INDIVIDUAL STUDIES (1-6)

- 597. SPECIAL TOPICS (1-6)

REAL ESTATE (R EST)

- 400. URBAN LAND UTILIZATION (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

*No graduate credit is given for this course.

CERAMIC SCIENCE (CERSC)

GUY E. RINDONE, *In Charge of Graduate Programs in Ceramic Science*
201 Steidle Building
814-865-6932

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bradt, McKinstry, Newnham, Rindone, Spear, Stubican, and Tressler.

Graduate Faculty: Associate Members Messing and Pantano.

This program is one of the options in which a graduate student in the Department of Materials Science and Engineering can receive an advanced degree. In view of the wide field covered by ceramic science, the graduate courses may be selected with special emphasis in physical ceramics, chemical ceramics, or glass science.

The communication and foreign language requirement may be satisfied by (1) examinations in two languages, or (2) examination in one foreign language *and* either 6 credits of computer science or 6 credits of statistics, or 3 credits of computer science and 3 credits of statistics.

Special facilities exist for research in the areas of electroceramics, rheology, phase equilibria, solid state synthesis, mechanical properties, ferrite and ferroelectric studies, glass science, surface characterization and properties, high temperature reaction kinetics, and corrosion studies. Suitable preparation for graduate study in this program may be found in one of the material sciences such as ceramics or metallurgy, in engineering fields such as chemical or mechanical engineering, in the basic physical sciences, or in the earth sciences.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

CERAMIC SCIENCE AND ENGINEERING (CERSE)

- 400. NONMETALLIC CRYSTAL CHEMISTRY (2-3) *Newnham*
- 402. PRINCIPLES OF CERAMIC ENGINEERING (3) *Messing*
- 404. CERAMIC SEMINAR (1)
- 406. RHEOLOGY AND FLUID PROPERTIES OF CERAMIC SYSTEMS (2) *Messing*
- 407. CERAMIC MATERIALS LABORATORY (2) *Messing*
- 408. THERMAL PROPERTIES OF CERAMIC MATERIALS (2) *Spear*
- 409. THERMAL PROPERTIES OF CERAMIC MATERIALS LABORATORY (2) *Spear*
- 410. PHASE RELATIONS IN CERAMIC SYSTEMS (3) *Spear*
- 411. PRINCIPLES OF CERAMIC PROCESSES (2) *Stubican*
- 414. MECHANICAL PROPERTIES OF CERAMICS (3) *Bradt*
- 415. PRINCIPLES OF GLASS TECHNOLOGY (3-4) *Rindone*
- 420. REFRACTORIES (2-3) *Stubican*
- 430. ELECTROCERAMICS (2) *Tressler*
- 431. ELECTROCERAMICS LABORATORY (1) *Tressler*
- 440. CARBON AND GRAPHITE (1) *Thrower*
- 441. CERAMIC NUCLEAR MATERIALS (1) *Spear*
- 496. INDEPENDENT STUDIES (1-12)

CERAMIC SCIENCE (CERSC)

- 500. SEMINAR IN CERAMIC SCIENCE (1-2 per term) Current developments in ceramic science and related fields. Required of all graduate students in ceramic science.
- 501. SURFACE BEHAVIOR OF CERAMIC MATERIALS (2-4) Surface chemistry of ceramics. Rheology of ceramic powders, suspensions, and pastes.

502. MECHANICAL PROPERTIES OF CERAMICS I (2) Theoretical considerations of the crystallographic and microstructural aspects of the elastic properties and fracture characteristics of ceramics. Prerequisite: Cersc. 414 or E.Mch. 415. *Bradt*
504. SOLID STATE REACTIONS IN CERAMIC SYSTEMS (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452. *Stubican*
505. PHASE TRANSITION IN SOLIDS (2) Phase transitions will be studied in detail with respect to the crystal structure, free energy, and physical properties. *McKinstry*
506. MECHANICAL PROPERTIES OF CERAMICS II (2) Theoretical considerations of dislocation processes, diffusion phenomena, and microstructural effects on the deformation and creep of ceramic materials. Prerequisite: Cersc. 502. *Bradt*
507. THERMAL PROPERTIES OF CERAMIC MATERIALS (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Tressler*
508. DIELECTRIC AND MAGNETIC PROPERTIES OF CERAMIC MATERIALS (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials. *Newnham*
509. COMPOSITE MATERIALS (3) Manufacturing processes, atomic and molecular background, and topological relationships of macro- and microstructure to the physical properties of composites. *Tressler*
510. SEMINAR IN GLASS TECHNOLOGY (1-2 per term) Current developments in glass technology and related fields. *Pantano*
511. THE CONSTITUTION OF GLASS (2-3 per term) Historical and current concepts of the atomic structure of glass; relationship of structure to chemical and physical properties. *Rindone*
596. INDIVIDUAL STUDIES (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

NOTE: Courses in the use of X-ray diffraction, electron microscopy, and the electron microprobe in ceramic science studies are listed under Materials Science.

CHEMICAL ENGINEERING (CH E)

LEE C. EAGLETON, *Head of the Department*
160 Merrell R. Fenske Laboratory
814-865-2574

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barton, Braun, Danner, Daubert, Duda, Eagleton, Engel, Kabel, Klaus, Ultman, and Vannice.

Graduate Faculty: Associate Members Peiffer and Tarbell.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, kinetics, catalysis, transport phenomena, unit operations and processes, optimization, polymer physics, bioengineering, process dynamics, mathematical modeling, applied chemistry, surface and colloid chemistry, petroleum technology, rheology, and lubrication. A foreign language is not required for the Ph.D. degree.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Applicants attending foreign universities are required to submit Graduate Record Examination scores. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

CHEMICAL ENGINEERING (CH E)

- 401. CHEMICAL PROCESS ENGINEERING (3)
 - 408. CHEMICAL ENGINEERING LABORATORY II (2)
 - 413. MASS TRANSFER OPERATIONS (4)
 - 414. KINETICS AND INDUSTRIAL CHEMISTRY (4)
 - 415. MATHEMATICAL MODELING IN CHEMICAL ENGINEERING (3)
 - 416. TECHNIQUES OF PROCESS DESIGN (3)
 - 420. CRYOGENIC ENGINEERING (3)
 - 422. MODERN PETROLEUM TECHNOLOGY — PROCESSES AND PRODUCTS (3)
 - 430. NUCLEAR CHEMICAL ENGINEERING (3)
 - 431. ADVANCED INDUSTRIAL CHEMISTRY APPLICATIONS (3)
 - 440. CHEMICAL ENGINEERING MATERIALS (3)
 - 441. POLYMER PROCESSING (3)
 - 445. PROJECTS IN CHEMICAL ENGINEERING (1-6)
 - 446. INTRODUCTION TO TRANSPORT PHENOMENA (3)
 - 448. ADVANCED MASS TRANSFER OPERATIONS (3)
 - 450. PROCESS DYNAMICS (3)
 - 453. THERMODYNAMICS FOR CHEMICAL ENGINEERS (3)
 - 455. CHEMICAL REACTOR DESIGN (3)
 - 460. CHEMICAL ENGINEERING (4)
 - 464. DESIGN OF CHEMICAL PLANTS (2)
 - 465. DESIGN PROJECTS IN CHEMICAL ENGINEERING (1-6)
 - 497. SPECIAL TOPICS (1-6)
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- 507. SIMULATION AND MODELING (3) Synthesis of subsystem and system models emphasizing the generality of the principles for application to diverse physical and chemical processes.
 - 509. HEAT TRANSFER APPLICATIONS (3) Advanced treatment of steady-state and transient conduction, convection, and radiation, with emphasis on numerical methods and design techniques. Prerequisite: an undergraduate course in heat transfer. *Daubert*
 - 516. METHODS OF PROCESS DESIGN (3) Survey of mathematical techniques of chemical process design with emphasis on economic choice and optimal decision making. *Engel*
 - 524. CHEMICAL ENGINEERING, APPLICATION OF THERMODYNAMICS (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.
 - 535. CHEMICAL REACTION ENGINEERING (3) Optimal design of batch and continuous chemical reactors and reactor batteries; effect of mixing on reactor operation.
 - 536. HETEROGENEOUS CATALYSIS (3) Thermodynamics and kinetics of adsorption and reactions on solid surfaces, heat and mass transfer effects, theory and correlations in catalysis. Prerequisite: Chem. 451, 452.
 - 545. TRANSPORT PHENOMENA I (3) Momentum, heat, and mass transfer, steady and unsteady state, laminar and turbulent flow, coupling, analogies, chemical engineering applications.
 - 546. TRANSPORT PHENOMENA II (3) Momentum, heat, and mass transfer, steady and unsteady state, laminar and turbulent flow, coupling, analogies, chemical engineering applications.
 - 548. MULTISTAGE MASS TRANSFER OPERATIONS (3) Rigorous solution of complex problems in distillation, extraction, and absorption including computer methods. Prerequisite: an undergraduate course in mass transfer. *Barton*
 - 596. INDIVIDUAL STUDIES (1-6)
 - 597. SPECIAL TOPICS (1-6)
 - 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

CHEMISTRY (CHEM)

JOSEPH A. DIXON, *Head of the Department*
 152 Davey Laboratory
 814-865-6553

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Allcock, Anderson, Ascah, Benkovic, Bernheim, Deno, Dixon, Fritz, Geoffroy, Gold, Haas, Hamilton, Heicklen, Hisatsune, Horrocks, Jackman, Jordan, Juks, Lampe, Lowe, Olofson, Richey, Rosenblatt, Shamma, Skell, Steele, Villafranca, Wartik, Weinreb, Winograd, and Zook.

Graduate Faculty: Associate Members DeShong, Garrison, Matthews, Minard, and Sen.

The Ph.D. program in chemistry provides students with a broad background in one of the areas of chemistry (analytical, biological, inorganic, organic, or physical) and intensive research experience culminating in the preparation of a formal thesis. The goal of the program is to prepare students for a variety of careers in academia, government, or industry. The general facilities are excellent, and the computer, cryogenic, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussions each Thursday at a departmental colloquium.

The department requires a knowledge of French, German, Japanese, or Russian as a condition for awarding either the M.S. or Ph.D. degree. Candidates who have taken and passed two undergraduate courses in French, German, Japanese, or Russian will be certified as having completed the communication and foreign language requirement. For the M.S. degree the student has the option of writing a thesis or a paper.

For admission, at least integral calculus plus one year's work in general physics, organic chemistry, physical chemistry, and either analytical or inorganic chemistry is normally required. Students who have appropriate course backgrounds and who present a 2.50 average in all undergraduate courses in chemistry, physics, and mathematics will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Prior to scheduling their first term programs, new students will take placement examinations in the areas of analytical, inorganic, organic, and physical chemistry. The information obtained from these tests will assist both the student and the adviser in making up a program best suited to the student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

- 400. CHEMICAL LITERATURE (1)
- 408. (Cmp.Sc. 408) COMPUTER APPLICATIONS IN CHEMISTRY (3)
- 410. INORGANIC CHEMISTRY (2)
- 411. ADVANCED INORGANIC CHEMISTRY (2)
- 426. CHEMICAL INSTRUMENTATION (3)
- 427. INSTRUMENTAL ANALYSIS (2)
- 428. INSTRUMENTAL ANALYSIS (2)
- 429. INSTRUMENTAL ANALYSIS (2)
- 431. ORGANIC AND INORGANIC PREPARATIONS (3)
- 439. STRUCTURAL ANALYSIS OF ORGANIC COMPOUNDS (3)
- 448. SURFACE CHEMISTRY (2)
- *451-452. PHYSICAL CHEMISTRY (3 each)
- 453. THERMODYNAMICS OF CHEMICAL SYSTEMS (3)
- 454. INTRODUCTION TO QUANTUM CHEMISTRY (3)
- 455. PHYSICAL CHEMISTRY OF HIGH POLYMERS (3)
- *457. EXPERIMENTAL PHYSICAL CHEMISTRY (1-2)
- *458. EXPERIMENTAL PHYSICAL CHEMISTRY (1-2)
- †489. INTRODUCTION TO CHEMICAL RESEARCH (1-10 per term, maximum of 20)

*Graduate credit not allowed for students majoring in chemistry or chemical engineering.

†Graduate credit not allowed for students majoring in chemistry.

500. SEMINAR IN CHEMISTRY (1 per term)
- 516-517. INORGANIC CHEMISTRY (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.
518. SPECIAL TOPICS IN INORGANIC CHEMISTRY (3 per term) Modern developments in specialized fields.
525. ANALYTICAL PROCESSES (3) Theoretical foundations and contemporary developments.
526. MODERN INSTRUMENTAL ANALYSIS (3)
527. SPECIAL TOPICS IN ANALYTICAL CHEMISTRY (2-12)
531. SPECIAL TOPICS IN ORGANIC CHEMISTRY (3-12) Prerequisite: Chem. 536.
534. CHEMICAL APPLICATIONS OF QUANTUM THEORY (3) A development of Molecular Orbital Theory up to the level of present-day usage in organic and inorganic chemistry.
- 535-536. ORGANIC REACTION MECHANISMS I AND II (3 each) Reaction mechanisms and their determination by kinetic and nonkinetic methods. Reactive intermediates. Prerequisite: Chem. 439.
537. SYNTHESIS IN ORGANIC CHEMISTRY (3) Theory and methods of directed syntheses, including stereospecific and stereoselective schemes; biologically inspired syntheses. Prerequisite: Chem. 536.
544. CHEMICAL THERMODYNAMICS (3) Development of thermodynamic theory with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.
545. STATISTICAL THERMODYNAMICS (3) The calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisites: Chem. 453 or 544, and Chem. 565.
560. TOPICS IN PHYSICAL CHEMISTRY (2-6)
563. CHEMICAL KINETICS (3) Theory and measurement of the rates of chemical reactions, molecular dynamics, and mechanisms of chemical reactions. Prerequisites: Chem. 453 or 544, and Chem. 565.
565. ATOMIC AND MOLECULAR STRUCTURE (3) Introduction to modern theoretical chemistry, spectroscopy, and structure of atoms and molecules.
566. QUANTUM CHEMISTRY (3) Theoretical calculations of electronic properties of atoms and molecules. Prerequisites: A.M. 432 and Chem. 565.
567. QUANTUM CHEMISTRY (3) A continuation of Chem. 566, including problems and theories of electron correlation. Prerequisite: Chem. 566.
571. POLYMER CHEMISTRY (3) The synthesis, reactions, and structure determination of high polymers.
589. STUDIES IN CHEMISTRY (1-9) Theoretical research, experimental research, or a critical survey of the literature in an area of chemistry.
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

CIVIL ENGINEERING (C E)

ROBERT M. BARNOFF, *Head of the Department*
212 Sackett Building
814-865-8391

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Aron, Barnoff, Cady, Crowley, Gotolski, Larson, Long, McDonnell, Miller, Nesbitt, Reed, Regan, Untrauer, Unz, Wang, West, and Willenbrock.

Graduate Faculty: Associate Members Anderson, Chadderton, Davinroy, Kibler, Marks, McClure, Mozingo, and Thomas.

Students may specialize in structures, hydraulics, hydrology, transportation engineering, traffic engineering, materials, construction, soils, and environmental engineering, or combinations of these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of one foreign language (French, German, or Russian) and proficiency in English. A thesis is required for the M.S. degree. An engineering report is required for the M.Eng. degree.

Candidates normally should be graduates from an accredited program in engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Entering graduate students for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 239).

See also Environmental Engineering.

CIVIL ENGINEERING (C E)

- 400. SEMINAR (1-3)
 - 421. TRANSPORTATION FACILITIES DESIGN (3)
 - 423. TRANSPORTATION SYSTEMS OPERATIONS (3)
 - 424. CIVIL ENGINEERING MATERIALS (3)
 - 427. RAILWAY TRACK STRUCTURE AND TERMINAL SYSTEMS (3)
 - 428. RAILWAY OPERATING SYSTEMS AND ANALYSIS (3)
 - 431. CIVIL ENGINEERING CONSTRUCTION (3)
 - 432. CONSTRUCTION PROJECT CONTROL (3)
 - 446. ADVANCED SOIL MECHANICS (3)
 - 447. STRUCTURAL ANALYSIS BY MATRIX METHODS (3)
 - 448. ADVANCED STRUCTURAL DESIGN (3)
 - 449. DESIGN OF PRESTRESSED AND REINFORCED CONCRETE STRUCTURES (3)
 - 451. ADVANCED HYDROLOGY (3)
 - 452. WATER RESOURCES AND COMPUTATIONS (4)
 - 462. OPEN CHANNEL HYDRAULICS (3)
 - 465. RIVER AND WATERWAYS ENGINEERING (3)
 - 471. ENVIRONMENTAL SANITATION (3)
 - 472. WATER POLLUTION CONTROL PROCESSES (3)
 - 473. WATER QUALITY MANAGEMENT (3)
 - 474. MANAGEMENT OF WATER POLLUTION CONTROL PROCESSES (3)
 - 475. WATER QUALITY CHEMISTRY (1)
 - 476. SOLID WASTE MANAGEMENT (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
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- 511. ENGINEERING SOIL CHARACTERISTICS (3) Physical and chemical factors in soil which influence their engineering properties of strength, deformation, permeability, and soil stabilization. Prerequisite: C.E. 44.
 - 512. APPLIED SOIL MECHANICS (2-5) Soil classification by type of clay minerals and profile development; aerial photographic interpretation of soils and applications to site selection for dams, highways, and airports. Prerequisites: C.E. 44 and 3 credits of geological sciences.
 - 513. SOIL EXPLORATION AND ANALYSIS (3) Laboratory evaluation of parameters used in modern soil mechanics. Involves techniques of soil testing, test limitations, sampling influences, technical reports. Prerequisite: C.E. 44.

518. **LAND USE MODELS (3)** The urban planning process; transportation models; economic, residential, industrial retail and public sector submodels; integrated models; simulation models; evaluative models. Prerequisite: 3 credits of computer science.
520. **PAVEMENT DESIGN (3)** Fundamental principles; properties of pavement components; design tests; design of flexible pavements; design of rigid pavements; pavement evaluation and strengthening. Prerequisites: C.E. 24, C.E. 44.
521. **TECHNIQUES OF TRANSPORTATION ANALYSIS (2-4)** Transportation functions, travel patterns, basic analytical methods in the planning content. Prerequisite: 3 credits of computer science.
522. **HIGHWAY OPERATIONS (2)** Theory and application of traffic controls, including functional operations of traffic signals, systems, and networks; the design of highway lighting. Prerequisite: C.E. 423.
523. **URBAN TRANSPORTATION PLANNING, TECHNOLOGY, POLICY, AND ADMINISTRATION (2-4)** Characteristics of urban areas, the urban transportation planning process, present and future urban transportation systems, urban transportation policy and administration. Prerequisite: C.E. 21.
524. **ADVANCED PROBLEMS IN CIVIL ENGINEERING MATERIALS (2-6)** Study, in the literature and by laboratory investigation, of selected topics on field-controlled civil engineering materials. Prerequisite: C.E. 424.
525. **AIRPORT PLANNING AND DESIGN (3)** Aircraft characteristics; aeronautical demand; site selection; airport configuration; capacity analysis; design of landing and terminal areas. Prerequisite: C.E. 21.
532. **POWER PLANT CONSTRUCTION (3)** Fossil and nuclear power generation; analysis of power plant design and civil, mechanical, and electrical construction phases; quality assurance role. Prerequisite: C.E. 431.
539. **APPROXIMATE METHODS OF STRUCTURAL ANALYSIS (3)** Newmark's method, finite difference method, and finite element method applied to problems in structural and soil engineering. Prerequisite: C.E. 40.
540. **STRUCTURAL ANALYSIS BY CLASSICAL METHODS (3)** Analysis of continuous trusses and beams, frames, arches, grids, curved beams, suspension systems, and space frames. Prerequisite: C.E. 40.
541. **STRUCTURAL ANALYSIS (3)** Analysis of continuous beams and frames, grids, slabs, shells and three-dimensional structural and soils problems by finite element methods. Prerequisite: C.E. 447.
544. **REINFORCED CONCRETE STRUCTURES (3)** Working stress, ultimate strength, and limit design; test behavior of beams, columns, and slabs. Prerequisite: C.E. 41.
545. **DESIGN OF METAL STRUCTURES (3)** Steel, aluminum members; flexible connections; composite, hybrid, prestressed beams; tension-field beams; buckling; plastic analysis, design; test data; timber design. Prerequisite: C.E. 342.
546. **THIN CONCRETE STRUCTURES (3)** Design of thin concrete structures including slabs, folded plates, and shells. Prerequisite: C.E. 41.
548. **STRUCTURAL DESIGN FOR DYNAMIC LOADS (3)** Dynamic behavior of structural systems of one and more degrees of freedom; earthquake, blast-resistant analysis, and design of structures. Prerequisites: E.Mch. 12 and C.E. 40.
550. **ENGINEERING CONSTRUCTION MANAGEMENT (3)** Management fundamentals for construction contracting; organization, project planning, scheduling and control, bonding and insurance, labor legislation and regulation, cost and control. Prerequisite: C.E. 431.
551. **HYDROLOGIC INVESTIGATIONS (2-8)** Application of hydrologic principles and techniques to a specific project. Prerequisite: C.E. 451 or 452.
552. **HYDROLOGIC PROCESSES AND CYBERNETICS (3)** Application of cybernetic concepts in electronic computer simulation of the hydrologic process-components: infiltration, precipitation, evapotranspiration, and overland flow. Prerequisite: C.E. 51 or 452.

553. **PLANNING MULTIPURPOSE HYDROLOGIC SYSTEMS (3)** Study of multipurpose hydrologic schemes within a social, economical, and political framework. Prerequisite: C.E. 451 or 452; Econ. 14.
554. **URBAN HYDROLOGY (3)** Several hydrograph methods. Design storm and IUH application; airport drainage; flood plains; impact of urbanization upon groundwater and sediment. Prerequisite: C.E. 451 or 452.
560. **DIMENSIONAL ANALYSIS AND THEORY OF MODELS (3)** Principles of dimensional analysis and similitude with engineering applications primarily to problems in hydromechanics. Prerequisite: C.E. 61.
564. **HYDRAULIC ENGINEERING DESIGN (3)** Design and analysis of selected units of a typical hydraulic engineering project. Prerequisite: C.E. 62.
570. **PHYSICAL CHEMICAL TREATMENT PROCESSES I (2)** The theory of physical-chemical processes used in the treatment of potable water and municipal and industrial wastewaters. Prerequisite: C.E. 472.
571. **PHYSICAL CHEMICAL TREATMENT PROCESSES II (3)** The theory of physical-chemical processes used in the treatment of potable water and municipal and industrial wastewaters. Prerequisite: C.E. 472.
572. **BIOLOGICAL TREATMENT PROCESSES (2)** The theory of biological processes used in the treatment of municipal and industrial wastewaters. Prerequisite: C.E. 472.
574. **LABORATORY ANALYSES IN WATER QUALITY CONTROL (3)** Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control. Prerequisite: Chem. 14.
575. **INDUSTRIAL WASTE TREATMENT (2)** Surveys and data analysis; use of unit processes to meet regulatory agency requirements; disposal of gaseous and solid residues. Prerequisite: C.E. 472.
577. **TREATMENT PLANT DESIGN (1-6)** Design of works for the treatment of water and wastewater for municipalities and industries. Prerequisites: C.E. 472 and 3 credits in hydraulics.
579. **(Micrb. 529) AQUATIC MICROBIOLOGY (3)** Ecology and physiology of microorganisms of inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.
580. **STREAM AND ESTUARINE ANALYSIS (3)** Quantitative assessment of advection, reaction, and dispersion processes in polluted waters; reaeration theory; eutrophic systems; analog simulation. Prerequisite: C.E. 472.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

CLASSICS (CLASS)

ARCHIBALD ALLEN, *Head of the Department*
109 Carnegie Building
814-865-8851

Degree Conferred: M.A.

Graduate Faculty: Senior Members Carrubba and Donlan.

Graduate Faculty: Associate Member Allen.

The master's degree in classics is intended either as a terminal degree which (combined with the appropriate courses in educational theory and technique) equips students to teach at the elementary or secondary school level, or as preliminary to further graduate study at the doctoral level. The program allows

specialization in either Latin or Greek but not to the exclusion of the other language. Although 18 undergraduate credits in some combination of Latin and Greek are the normal minimum requirements for admission, candidates can be admitted with deficiencies in the languages if these are compensated by training in ancient history, civilization, or archaeology. The required 2.50 grade-point average in junior-senior courses, normally considered a minimum for admission, will also be waived in special cases.

Of the 30 graduate credits required for the M.A., 6 may take the form of a supervised thesis. Candidates who choose not to submit a thesis must schedule 6 additional credits of course work. Besides the courses listed below, offered by the Department of Classics, candidates may schedule up to 9 credits in appropriate related subjects — such as ancient history, ancient philosophy, art history, or linguistics — offered by the respective departments. The comprehensive examination comprises a translation paper in either Latin or Greek, an essay exam in three areas of the student's choice in Greek and Latin literature, and a reading examination in a modern language (normally French or German).

GREEK (GREEK)

- 401. INTRODUCTORY READINGS IN GREEK LITERATURE (3)
- 420. THE GREEK HISTORIANS (3)
- 421. GREEK TRAGEDY (3)
- 422. GREEK COMEDY (3)
- 431. PLATO (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 507. PROBLEMS IN GREEK ARCHAEOLOGY (3-9)
- 509. GREEK SEMINAR (3-9)
- 517. GREEK RESEARCH (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

LATIN (LATIN)

- 401. INTRODUCTORY READING IN LATIN LITERATURE (3)
- 402. LATIN LITERATURE OF THE REPUBLIC (3-9)
- 403. LATIN LITERATURE OF THE AUGUSTAN AGE (3-9)
- 404. LATIN LITERATURE OF THE EMPIRE (3-9)
- 437. LATIN PROSE COMPOSITION (3-6)
- 461. (Ling. 461) HISTORY OF THE LATIN LANGUAGE (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 500. LATIN LITERATURE (3-9) Readings in the major forms of Latin literature; content varies; course may be repeated.
- 510. LATIN SEMINAR (3-6)
- 518. LATIN RESEARCH (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

***CLASSICS (CLASS)**

- 405. STUDIES IN GREEK MYTHOLOGY (3)
- 408. GREEK RELIGION AND MODERN MAN (3)
- 410. CLASSICAL EPIC (3)
- 411. CLASSICAL DRAMA (3)
- 496. INDEPENDENT STUDIES (1-12)

*The readings are in English; knowledge of Greek and Latin is not required.

500. INTRODUCTION TO CLASSICAL SCHOLARSHIP (1-6) Lectures on the methods and materials of classical scholarship. To be scheduled by graduate students in their first term and as necessary thereafter.

504. TOPOGRAPHY OF ANCIENT ROME (3) Lectures and readings on physical development of the ancient city of Rome from earliest habitation to time of later empire.

597. SPECIAL TOPICS (1-6)

COMMUNICATION DISORDERS (CMDIS)

FREDERICK F. WEINER, *In Charge of Graduate Programs in Communication Disorders*
110 Moore Building
814-865-5414

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Frank, Frick, Gilbert, Michael, Moores, Siegenthaler, and Weiner.

Graduate Faculty: Associate Members Klevans and Volz.

Students may specialize in speech pathology, audiology, or education of the hearing impaired. The programs include the requirement of a number of field trips to diagnostic and treatment facilities and may include a period of internship at an off-campus location to be assigned by the staff. Students should expect to have moderate expenses related to these trips.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages. The nonthesis option is available for the M.S. degree.

Approximately 38 credits are required for admission, distributed among speech pathology, audiology, education of the hearing impaired, speech science, education, and psychology, and including a course in statistics. Students entering without an undergraduate program in the field may be required to take additional make-up work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Although occasionally admitted for the summer term, new master's students in the speech pathology option generally are admitted to the option only in the fall term.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

- 430. INTRODUCTION TO AUDIOLOGY (3)
- 433. VISUAL SPEECH RECEPTION AND AUDITORY TRAINING (3)
- 439. PRACTICUM IN AUDITORY TRAINING AND SPEECH READING (1-5)
- 440. (E.E.C. 440) SURVEY OF SPEECH AND HEARING DISORDERS (3)
- 442. SPEECH PATHOLOGY I (3)
- 444. SPEECH PATHOLOGY II (3)
- 445. PROFESSIONAL PROGRAMS AND RELATIONSHIPS (3)
- 449. PRACTICUM IN SPEECH THERAPY (1-6)
- 459. PRINCIPLES OF CLINICAL MANAGEMENT IN S.P.A. (2)
- 460. COMMUNICATION SKILLS FOR HEARING IMPAIRED I (2)
- 461. COMMUNICATION SKILLS FOR HEARING IMPAIRED II (3)
- 462. CLINICAL BASES OF LANGUAGE DISORDERS (2)
- 463. TEACHING LANGUAGE TO THE HEARING IMPAIRED (3)
- 464-465. TEACHING SCHOOL SUBJECTS TO THE DEAF (2 each)
- 469. STUDENT TEACHING WITH THE DEAF (3-12)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

515. APPLICATION OF PHYSIOLOGICAL AND ACOUSTICAL CONCEPTS OF SPEECH PATHOLOGY AND AUDIOLOGY (4) Application of practical and theoretical concepts in neurology, physiology, and acoustics to communication disorders with implications for clinical therapy. Prerequisites: 6 credits in speech science and 6 credits in speech pathology and audiology.
516. APPLICATIONS OF PSYCHOLOGY OF SPEECH TO SPEECH PATHOLOGY AND AUDIOLOGY (1) Application of psychological concepts germane to theoretical and practical understanding of communication disorders; implications for clinical speech and language therapy. Prerequisites: 6 credits in speech pathology and audiology and 6 credits in psychology.
517. (Ling. 517) APPLICATIONS OF LINGUISTICS TO COMMUNICATION DISORDERS (1) Application of linguistic theory to the understanding of communication disorders, with clinical implications for speech and language therapy. Prerequisites: 12 credits in speech pathology and audiology, psychology, linguistics, or phonetics.
522. (Sp.Com. 522) SPEECH PERCEPTION (3) Transformation of linguistic units into acoustic speech signals, theories of speech perception, and auditory processing of the speech signal. Prerequisites: Sp.Com. 410, 431, 520.
530. SEMINAR IN AUDIOLOGY (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.
531. SPEECH AUDIOMETRY AND HEARING AIDS (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.
532. ACOUSTICAL INSTRUMENTS FOR HEARING (3) Acoustical instrumentation used for research in hearing, programs of hearing conservation, and noise control, including clinical and industrial applications. Prerequisite: 6 credits in acoustics, audiology, experimental psychology, or speech science at 400 level.
534. NOISE AND HEARING (3) Noise-induced hearing problems; interference with communication; annoyance and community problems caused by acoustic energy; regulations and standards. Prerequisite: 6 credits at the 400 level in acoustics, audiology, experimental psychology, or speech science.
535. PURE TONE AUDIOMETRY (3) Techniques, interpretation, and differential diagnosis of hearing ability by pure tone and related audiometric techniques. Prerequisites: S.P.A. 430, S.P.A. 433, Acs. 401; 6 credits in speech pathology and audiology.
538. PRACTICUM IN AUDIOLOGIC EVALUATION AND SELECTION OF HEARING AIDS (1-5) Prerequisite: S.P.A. 531.
539. ADVANCED PRACTICUM IN EDUCATION OF THE DEAF (1-6) Theoretical and clinical rationale of working with hearing impaired, professional role and relationships, therapy procedures, evaluation of process and outcomes. Prerequisite: S.P.A. 439.
540. ARTICULATION DISABILITIES (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.
541. THE VOICE AND ITS DISORDERS (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.
542. STUTTERING (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.
543. DIAGNOSTIC PROCEDURES IN CLINICAL SPEECH (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisite: S.P.A. 444.
544. CLEFT PALATE (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.
545. (E.E.C. 545) CEREBRAL PALSY (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multiprofessional habilitative program. Prerequisite: S.P.A. 444.

546. LANGUAGE DISORDERS IN ADULTS (3) Nature, etiology, diagnosis, and management of language disorders in adults. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.

547. (E.E.C. 547) LANGUAGE DISORDERS IN CHILDREN (2) Nature, etiology, diagnosis, and management of language disorders in children. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.

548. PRACTICUM IN SPEECH DIAGNOSIS (1-3) Supervised practice in interviewing, counseling, speech evaluation, and synthesis of psychological, medical, and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.

549. ADVANCED PRACTICUM IN SPEECH THERAPY (1-6) Theoretical and clinical rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.

550. SEMINAR IN SPEECH PATHOLOGY (1-6) Advanced study of special problems and new developments in speech pathology. Prerequisites : S.P.A. 442, 444.

560. RECENT DEVELOPMENTS IN EDUCATION OF THE DEAF (2-6) In-depth seminar-style study of communication disorders associated with deafness, and advanced and experimental attempts at remediation. Prerequisites: 8 credits in education of the deaf or audiology, S.P.A. 430 and 433, and 3 credits in child development or learning theory.

566. EDUCATION AND GUIDANCE OF THE HEARING IMPAIRED (3) Effects of hearing impairment on developmental, educational, social, and vocational adjustment; assisting the hearing impaired toward improved life adjustment. Prerequisites: S.P.A. 430, 433.

567. AUDIOLOGY FOR HEARING AND SPEECH CLINICIANS (3) Etiology, measurement, and differential diagnosis of hearing loss; overview of aural rehabilitation, including hearing aids and auditory training systems. Prerequisites: S.P.A. 430, S.P.A. 433; 6 credits in speech pathology and audiology.

596. INDIVIDUAL STUDIES (1-6)

COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (CSP D)

R. RICHARD RITTI, *Chairman of Graduate Programs in Community Systems Planning and Development*
S-210 Henderson Human Development Building
814-863-2492

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Arnold, Bullington, Freeman, Gamm, Gunter, Hunt, Katkin, Mann, Miller, Raffel, Ritti, Vallance, Woolley, and Young.

Graduate Faculty: Associate Members Eisele, Ellis, Fisher, Fox, Goodstein, Guttenplan, Hussey, Hyman, Kramer, Lee, Mayers, Meyer, Muller, Parsonage, and Sawyer.

This interdisciplinary program provides instruction in content and research methods relating to the coordinated planning, development, administration, and evaluation of a range of community services in the three professional areas of health and medical care services, justice services, and community social services.

The aim of the program is to build the knowledge base and skills necessary to develop policies and programs for the effective delivery of human services to individuals and communities. Graduates of the program will be able to identify major community subsystems and recognize community problems and dysfunctions, expressing their relative seriousness in terms of economic and social costs. Graduates will have skill in working with members of the community and with community institutions to develop ways of coping with such problems and to facilitate the creation of interventions which will improve the quality of life. In addition, they will have the skills necessary to evaluate the effectiveness of these interventions.

The Ph.D. program prepares professionals, researchers, and teachers with the necessary conceptual and technical skills to identify and analyze elements of human service systems and to develop, implement, and evaluate programs designed to improve the quality of life. Ph.D. students will develop considerable understanding of all human service systems and might elect to develop a master's level competency in one of the professional areas represented in the program. The communication requirements for the Ph.D. can be satisfied by demonstration of proficiency through examination in a foreign language or a set of computer languages. The M.S. program will prepare individuals for professional-level work in health planning and administration, administration of justice, or community social services. Career opportunities include administration and planning positions in hospitals and health facilities, community mental health, social services, criminal justice planning agencies, courts, and corrections programs. A thesis is required for the M.S. degree.

Preference will be shown to applicants who have a broad background in the social sciences. Proficiency in quantitative skills such as mathematics and statistics is also desirable. In general, a 3.00 junior-senior average is expected of applicants, but consideration will be given to prior graduate education and professional work experience.

Special research and training facilities include the Institute for the Study of Human Development and the University Computation Center.

COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (CSP D)

500. INTRODUCTION TO COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (3) Introduction to applied general systems theory; applications to analysis of community systems and to the planning of community human services.

501. HEALTH CARE ORGANIZATION (3) Examination of health systems, organization, financing, and evaluation; trends, problems, and issues.

505. UNDERSTANDING ORGANIZATIONAL BEHAVIOR (3) A systematic application of the principles of organizational behavior to understanding professional roles in human service organizations.

510. HEALTH PROBLEM ANALYSIS (3) Logic of empirical inquiry in study of community problems in health. Integration of theory and practice, technical data and values.

511. APPROACHES TO HEALTH PLANNING (3) A systematic exploration of approaches to health planning and an application of health planning techniques. Prerequisite: C.S.P.D. 510.

521. VALUES AND GOALS IN THE ADMINISTRATION OF JUSTICE (3) The justice system from perspective of clientele, service personnel, and the system. Meeting service requirements in community and institutional settings.

523. ISSUES AND TRENDS IN THE DEVELOPMENT OF SOCIAL WELFARE SERVICES (3-6) Examination of selected issues affecting the development of social welfare functions and services.

531. COMMUNITY DYNAMICS AND SOCIAL SERVICES (3) Classic and contemporary community organization theory, social planning and change, decision making, human services planning and action, community action, community research.

532. INTERFACE PROBLEMS OF COMMUNITY SERVICE SYSTEMS (3) Exploration of consequences of policy decisions and action in one or more social service systems on other community systems.

533. BEHAVIORAL ASSUMPTIONS AND STRATEGIES IN THE PROCESS OF PLANNED CHANGE (3) A general systems approach to the assumptions beneath various social problem strategies and consequences associated with each intervention-set.

534. FORECASTING METHODS AND SOCIAL POLICY PLANNING (3) Analysis of predictive methods for forecasting social change. Prerequisites: Econ. 405, Stat. 200.

540. MANAGEMENT OF HEALTH SERVICES ORGANIZATIONS (3) A systematic study of the roles of health services managers and the organizational and environmental context within which they work. Prerequisites: C.S.P.D. 505, 532.

542. HOSPITAL AND HEALTH SERVICES ADMINISTRATION (3) A study of decision making in hospitals and health organizations; the process of decision making, incorporating various techniques and strategies. Prerequisites: C.S.P.D. 501, 540, 545, Q.B.A. 521.

545. FINANCIAL MANAGEMENT IN HEALTH INSTITUTIONS (3) Financial environment of health institutions; financial aspects of management decision-making; emphasis on revenue sources, budgeting, and cost control.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

COMPARATIVE LITERATURE (C LIT)

CAROLINE D. ECKHARDT, *In Charge of Graduate Programs in Comparative Literature*
N424 Burrowes Building
814-863-0589

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Begnal, Carrubba, Ebbinghaus, Frank, Hale, Kopp, Lewis, Lima, Peavler, Walden, Ward, Weintraub, and West.

Graduate Faculty: Associate Members Balaban, Eckhardt, Fitz, Grecco, Hale, and Knight.

Programs of study combine a core of comparative literature courses with courses in several national literatures (two for the master's degree and three for the doctoral degree) according to the student's interests. These programs can be designed to concentrate on such topics as genres, themes, periods, movements, folklore, criticism, the influence of literary works, and the relationships among national literatures and between literature and other disciplines.

Requirements for the M.A. degree include (1) 9 credits in comparative literature (3 credits of which must be C.Lit. 501), 9 credits in one national literature, and 6 credits in a second national literature; (2) proficiency in two foreign languages; (3) a written comprehensive examination based on a reading list; and (4) 6 thesis credits.

Students with a 3.00 junior-senior average and appropriate course backgrounds (including preparation in a foreign language) will be considered for admission to the master's program. Exceptions may be made for students with special backgrounds and abilities.

Requirements for the Ph.D. degree include (1) 9 credits in comparative literature (C.Lit. 501, 502, and 503, unless these have been part of the M.A. degree program) and at least 21 credits in either a concentration in national literatures or a concentration in a period, genre, theme, or area study; (2) an oral candidacy examination; (3) proficiency in three foreign languages; (4) a written comprehensive examination based on a reading list; and (5) a thesis.

Students holding or completing a master's degree in an appropriate field, and prepared to work in three national literatures, will be considered for admission to the doctoral program.

COMPARATIVE LITERATURE (C LIT)

400. SENIOR SEMINAR IN COMPARATIVE LITERATURE (3)

401. WESTERN LITERATURE I (3) *Eckhardt and Knight*

402. WESTERN LITERATURE II (3) *Knight and Condee*

403. WESTERN LITERATURE III (3) *Begnal and Peavler*

407. LITERATURE OF VOYAGE, TRAVEL AND DISCOVERY (3) *Martin*

408. HEROIC EPIC AND SONG (3) *Bayard, Thigpen, and Bowden*

422. AFRICAN DRAMA (3) *Hale*

423. AFRICAN NOVEL (3) *Hale*

443. (Ger. 443) LITERARY RELATIONS OF GERMANY WITH ENGLAND AND AMERICA (3-9) *Kopp and Lewis*

470. OLD MASTERS OF THE MODERN NOVEL (3) *Begnal and Ward*

480. INTRODUCTION TO FOLKLORE (3) *Thigpen*

- 486. TRAGEDY (3) *Grecco and Lima*
- 487. COMEDY (3) *Knight and Lima*
- 488. (Engl. 488) MODERN CONTINENTAL DRAMA (3) *Grecco*
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 500. SEMINAR IN COMPARATIVE LITERATURE (3-6)
- 501. COMPARATIVE METHOD IN LITERARY STUDIES (3) Bibliography, research methods, and studies in comparative literature. *Eckhardt and Ward*
- 502. COMPARATIVE CRITICISM I: CLASSICAL TO NEOCLASSICAL (3) Issues in literary criticism from Plato and Aristotle to the mid-eighteenth century. *Ward*
- 503. COMPARATIVE CRITICISM II: ROMANTIC TO CONTEMPORARY (3) Principles and theories of literary criticism from eighteenth- and nineteenth-century beginnings to twentieth-century expansion and application. *Ward*
- 508. NORSE AND GAELIC SAGAS (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to background, development, themes, and characteristics. *Bayard and Ebbinghaus*
- 570. FORCES IN CONTEMPORARY EUROPEAN LITERATURE (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *West*
- 588. TWENTIETH-CENTURY DRAMA (3) The comparative analysis of major plays of the twentieth century. *Grecco and Lima*
- 593. (Engl. 593) ANGLO-AMERICAN FOLK SONG (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present. *Bayard*
- 596. INDIVIDUAL STUDIES (1-6)

COMPUTER SCIENCE (CMPSC)

JONATHAN GOLDSTINE, *Acting Head of the Department*
 303 Whitmore Laboratory
 814-865-6553

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Cullk, deMaine, C. Fischer, P. Fischer, Goldstine, D. Johnson, Laird, and Seiferas.

Graduate Faculty: Associate Members Frederickson, Gudes, Heller, Irwin, Ja'Ja', G. Johnson, Laskowski, Simon, Spirn, Tsur, and Wotschke.

The department offers courses and is prepared to direct research in a variety of subfields of computer science, including data bases and information retrieval, foundations of computer science, analysis of algorithms, computational complexity, formal language theory, operating systems, and numerical analysis. The Computation Center has modern facilities available for research and instruction. The department operates a Computer Systems Laboratory for instruction.

Admission to the M.S. program without deficiency requires that an applicant should have completed at least 9 credits of computer science at the advanced undergraduate level from the areas of data structures, programming languages and compiler design, computer organization and operating systems, numerical analysis, and language and automata theory. In addition, the student is expected to have mathematics training which includes calculus, linear algebra, and some discrete mathematics.

The M.S. candidate must satisfactorily complete the requirements of the Graduate School. In addition, at least 12 of the required 500-level credits shall be regular courses in the Department of Computer Science meeting certain distribution requirements described in the departmental brochure, *Graduate*

Study in Computer Science at Penn State. The nonthesis option is available for the M.S. degree. The candidate may also be required to demonstrate proficiency in the design and implementation of computer programs or computer-related systems, or both.

The Ph.D. degree is primarily a research degree and is conferred on the basis of original work and high academic achievement in computer science. In order to be accepted as a candidate the student must pass a written candidacy examination. The communication and foreign language requirement for the Ph.D. degree may be satisfied by a proficiency in one foreign language (French, German, or Russian). These and additional requirements are detailed in the departmental brochure cited above.

Students with at least a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. The department requires scores on the Graduate Record Examination Aptitude Test from all applicants.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 239).

COMPUTER SCIENCE (CMPSC)

- 400. PROGRAMMING LANGUAGE CONCEPTS (3)
- 402. INTRODUCTION TO COMPUTER PROGRAMMING (3)
- 404. INFORMATION STRUCTURES (3)
- 408. (Chem. 408) COMPUTER APPLICATIONS IN CHEMISTRY (3)
- 410. COMPUTER ORGANIZATION AND OPERATION (3)
- 411. OPERATING SYSTEMS (3)
- 415. (E.E. 415) COMPUTER SYSTEMS ARCHITECTURE (3)
- 420. COMPILER CONSTRUCTION (3)
- 430. COMBINATORICS AND GRAPH THEORY (3)
- 440. INTRODUCTION TO DATABASE MANAGEMENT SYSTEMS (3)
- 442. ADVANCED PROGRAMMING AND JOB CONTROL LANGUAGE (3)
- 444. SYSTEMS AND PROGRAM DESIGN IN EDP (3)
- 453. (Math. 453) NUMERICAL COMPUTATIONS (3)
- 454. (Math. 454) MATRIX COMPUTATIONS (3)
- 468. MATHEMATICAL MACHINE THEORY (3)
- 491. COMPUTER PROJECTS (1-12)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 500. THEORY OF AUTOMATA (3) The structure of finite automata and sequential machines including characterization theorems, minimization problems, state identification experiments, and decomposition theory. Prerequisite: Cmp.Sc. 468.
- 510. PARSING, TRANSLATION, AND COMPILING (3) Principles of compiler design: lexical analysis, parsing methods, semantic analysis, code generation, and optimization. Prerequisites: Cmp.Sc. 420, 468.
- 511. OPERATING SYSTEMS (3) Concurrent processes, synchronization and deadlock, scheduling models, queueing models, memory management, and security. Prerequisites: Cmp.Sc. 411; Stat. (Math.) 418.
- 530. MACHINE INTELLIGENCE AND HEURISTIC PROGRAMMING (3) Methods for making machines behave intelligently; problem solving, theorem proving, game playing, question answering, learning, induction; specialized languages and data structures. Prerequisite: Cmp.Sc. 420.
- 534. ALGORITHM DESIGN AND ANALYSIS (3) Data structures and programming techniques useful in the design of efficient algorithms; algorithm analysis; computational complexity. Prerequisite: Cmp.Sc. 404.
- 535. THEORY OF GRAPHS AND NETWORKS (3) Theory and applications of graphs including structure of graphs, network analysis, and algorithms for computer solution of graph-theoretic problems. Prerequisite: Cmp.Sc. 430.

537. (B.A. 537) **MANAGEMENT INFORMATION SYSTEMS DESIGN (3)** Cost, value, and technical considerations in analysis and design of information systems whose purposes are to aid decision making in organizations.
540. **INFORMATION PROCESSING SYSTEMS (3)** Data structures and data processing; information retrieval systems. Prerequisite: Cmp.Sc. 411.
545. **INFORMATION RETRIEVAL (3)** Input-output, design, implementation, evaluation, global memories, and comparison of information retrieval systems. Prerequisite: Cmp.Sc. 540.
551. (Math. 551) **NUMERICAL ALGEBRA (3)** Zeros of polynomials; iterative solution of linear and nonlinear systems; sparse matrix techniques; eigenvalues and eigenvectors. Prerequisite: Cmp.Sc. 454 or Math. 441.
552. (Math. 552) **INTRODUCTION TO APPROXIMATION THEORY (3)** Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 3 credits in computer science.
553. (Math. 553) **NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS (3)** Methods for initial value and boundary value problems. Stability and convergence analysis, automatic error control, and stiff systems. Prerequisites: Cmp.Sc. 453, Math. 431.
559. **COMPUTABILITY AND RECURSIVE FUNCTIONS (3)** Mathematical treatment of computability, recursive functions, Turing machines, unsolvable problems, recursive and recursively enumerable sets. Prerequisite: Cmp.Sc. 468.
564. (Math. 564) **NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS (3)** Methods of parabolic, hyperbolic, and elliptic partial differential equations; finite difference and variational methods; splines, finite elements. Prerequisites: Cmp.Sc. 453, 454; A.M. (Math) 451 or 432.
- 568-569. **THEORY OF FORMAL LANGUAGES AND AUTOMATA (3 each)** Generation and recognition of formal languages, grammars, Chomsky's hierarchy of languages, closure properties, characterization by automata, algebraic properties, complexity classification. Prerequisite: Cmp.Sc. 468.
579. (Math. 579) **SPECIAL TOPICS IN NUMERICAL ANALYSIS (2-12)**
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

COUNSELOR EDUCATION (CN ED)

EDWIN L. HERR, *Head of the Division of Counseling and Educational Psychology*
201 Carpenter Building
814-865-3427

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Baker, Britton, Herr, Horan, Hudson, Keat, Kelz, and Swisher.

Graduate Faculty: Associate Members Craighead, Moore, and Scofield.

Professional preparation is offered at the master's level for school counselors (elementary and secondary), college counselors or persons entering college student personnel services, and rehabilitation counselors. Doctoral programs prepare candidates for positions of responsibility and leadership in these same areas, as well as in the education of counselors and in counseling research and practice. Doctoral candidates must have a minimum of one year of work experience in their field.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a comprehensive knowledge of one foreign language and courses from other designated areas, or by options from designated areas selected to include competence in statistics, research design, computer application, or electronic data processing.

All candidates for graduate degrees in counselor education must present for admission at least 27 undergraduate credits of 3.00 or better, distributed among at least three of the following areas: economics, education, psychology, sociology, and physiology or anatomy.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Doctoral candidates should present at least a 3.33 average in all graduate study completed.

All candidates are expected to exhibit, in addition to academic competence, effectiveness in interpersonal relations and in both written and oral communication. They must also evidence support of professional counseling activities and organizations.

COUNSELOR EDUCATION (CN ED)

- 403. FOUNDATIONS OF GUIDANCE AND COUNSELING PROCESSES (3)
 - 404. GROUP PROCEDURES IN GUIDANCE AND COUNSELING (3)
 - 408. INTRODUCTION TO VOCATIONAL REHABILITATION (3)
 - 409. MEDICAL INFORMATION FOR COUNSELORS (3)
 - 410. REHABILITATION OF THE MENTALLY ILL (3)
 - 412. REHABILITATION FACILITIES AND SERVICES OF PENNSYLVANIA (3)
 - 413. REHABILITATION CASE RECORDING AND MANAGEMENT (3)
 - 415. COUNSELING ADULTS (3)
 - 417. (Vo.Ed. 417v) CAREER EDUCATION: ORIGINS, THEORY, IMPLEMENTATION (3)
 - 425. THE USE OF TESTS IN COUNSELING (3)
 - 470. WORKSHOP IN STUDIES IN COUNSELOR EDUCATION (1-6)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
501. COUNSELING THEORY AND METHOD (3) Theory and methods of counseling individuals whose problems of choice, decision, and adjustment fall within the normal range. Prerequisite: a G.P.A. of at least 3.00 in 27 credits from 3 of 5 areas: anatomy and physiology, economics, education, psychology, and sociology.
502. ADVANCED COUNSELING THEORY AND METHOD (3) Assessment, intervention, and evaluation procedures for counseling problems frequently encountered in school, college, and rehabilitation settings. Prerequisite: Cn.Ed. 501.
503. GUIDANCE SERVICES IN ELEMENTARY EDUCATION (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals. Prerequisite: a G.P.A. of at least 3.00 in 27 credits from 3 of 5 areas: anatomy and physiology, economics, education, psychology, and sociology.
504. GUIDANCE SERVICES IN SECONDARY EDUCATION (3) Nature and scope of guidance in secondary schools — services, models, and strategies; the counselor as an agent of change. Prerequisite: a G.P.A. of at least 3.00 in 27 credits from 3 of 5 areas: anatomy and physiology, economics, education, psychology, and sociology.
505. FOUNDATIONS OF COUNSELING INFORMATION (3) Accelerating change in economic, psychological, social, educational influences upon counselees. Utilization of information systems in effecting counselee change. Prerequisite: a G.P.A. of at least 3.00 in 27 credits from 3 of 5 areas: anatomy and physiology, economics, education, psychology, and sociology.
506. INDIVIDUAL ANALYSIS AND COUNSELING PROCEDURES (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing. Prerequisites: Cn.Ed. 425, 501, 505.
507. COUNSELING PRACTICUM (1-6) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Cn.Ed. 506.

508. ORGANIZATION AND ADMINISTRATION OF GUIDANCE PROGRAMS (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: a G.P.A. of at least 3.00 in 27 credits from 3 of 5 areas: anatomy and physiology, economics, education, psychology, and sociology.
509. CONTRIBUTIONS OF PROFESSIONAL PERSONNEL TO VOCATIONAL REHABILITATION (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisites: Cn.Ed. 403, 408.
511. SUPERVISED PRACTICUM IN REHABILITATION COUNSELING (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Cn.Ed. 403, 408.
512. PROFESSIONAL EXPERIENCE IN REHABILITATION COUNSELING (1-10) Supervised internship with responsibility for a regular case load. Prerequisites: Cn.Ed. 403, 409, 501, 507.
513. SUPERVISION OF COUNSELORS (3-9) Practical experience in supervising and evaluating work of counselors. Prerequisite: Cn.Ed. 507.
516. EVALUATION OF PROJECTS IN SCHOOL GUIDANCE (2-6) Implementation and evaluation of program development projects in cooperation with state or local guidance programs. Prerequisite: 15 credits in counselor education.
517. ELEMENTARY SCHOOL COUNSELING INTERNSHIP AND SEMINAR (1 per term, maximum of 3) Off-campus, supervised internships in elementary school settings with supplementary related topics, discussion, and skills training in on-campus seminars. Prerequisite: Cn.Ed. 503.
518. SECONDARY SCHOOL COUNSELING INTERNSHIP AND SEMINAR (1 per term, maximum of 3) Off-campus, supervised internships in secondary school settings with supplementary related topics, discussion, and skills training seminars. Prerequisite: Cn.Ed. 504.
551. STUDENT PERSONNEL SERVICES (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; cocurricular activities; student welfare.
553. STUDENT PERSONNEL SERVICES PROGRAMMING (2-3) Formulation of policies as guides to the student personnel service programs; integration of program elements; research; current problems and trends. Prerequisites: Cn.Ed. 551, Hi.Ed. 545.
555. CAREER COUNSELING (3) The examination of historical, legislative, and current models of career counseling and the development of pertinent individual and group techniques. Prerequisite: Cn.Ed. 505.
591. SEMINAR IN COUNSELING: HISTORY AND TRENDS (1) Discussion of the history of guidance and counseling, emphasizing how the past has shaped the present and portends the future. Prerequisite: 9 credits in counselor education.
592. SEMINAR IN COUNSELING: LEGAL AND ETHICAL CONCERNS (1-2) Study and discussion of legal, ethical, and professional concerns of counselors; privileged communication, data banks, and privacy invasion. Prerequisite: 9 credits in counselor education.
593. SEMINAR IN COUNSELING: PHILOSOPHY (1) Study and discussion of such philosophical foundations of counseling as phenomenology, idealism, realism, existentialism, and daseinanalytic, theological, and other contemporary thoughts. Prerequisite: 9 credits in counselor education.
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

CURRICULUM AND INSTRUCTION (C I)

CAROL A. CARTWRIGHT, *In Charge of Graduate Programs in Curriculum and Instruction*
155 Chambers Building
814-865-5433

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Alessandro, Askov, Bell, Bixby, Bliesmer, Brewer, Cartwright, M. Dupuis, V. Dupuis, Dwyer, Fagan, Fowler, Golub, Heilman, Heimer, Hermanowicz, Koble, Madsen, Searles, Shemick, Short, Shrigley, Szabo, Trueblood, Welliver, Withall, F. Wood, Yawkey, and Zaffaroni.

Graduate Faculty: Associate Members Hogg, Johnson, Marbach, Nelson, Nicely, and Sharp.

This program provides advanced professional preparation in the special areas of supervision and curriculum development, bilingual education, early childhood education, elementary education, instructional media, language arts and reading, science education, social studies education, and mathematics education. Candidates for the Ph.D. and D.Ed. degrees must meet all requirements, described in the earlier sections of this catalog. To meet residency requirements, the Ph.D. candidate must spend at least three consecutive terms enrolled as a full-time student at the University Park Campus. The D.Ed. candidate must spend at least three of any five consecutive terms enrolled as a full-time student at the University Park Campus.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages.

Candidates for the D.Ed. degree with a minor in curriculum and instruction must take a minimum of 15 course credits approved in advance by the person in charge of graduate programs in curriculum and instruction. Candidates for the M.Ed. degree with a minor in curriculum and instruction must take a minimum of 6 course credits approved in advance.

For admission to the professional degrees of M.Ed. and D.Ed., teaching or equivalent experience and at least 18 credits in education are recommended. Students with a 2.75 junior-senior average and with appropriate course and professional backgrounds will be considered for admission, subject to the limitation of program facilities.

CURRICULUM AND INSTRUCTION (C I)

- 410. SECONDARY TEACHING I (2)
- 411. SECONDARY TEACHING II (2)
- 412. SECONDARY TEACHING III (2)
- 413. CLINICAL APPLICATION OF INSTRUCTION AND MANAGEMENT SKILLS (2 per term, maximum of 6)
- 414. PRACTICUM IN STUDENT TEACHING — N-12 (12)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

CURRICULUM AND SUPERVISION (C & S)

- 400. INTRODUCTION TO RESEARCH LITERATURE (3)
- 401. MEASUREMENT AND EVALUATION OF INSTRUCTION, K-12 (3)
- 405. STRATEGIES IN CLASSROOM MANAGEMENT (3)
- 451. INSTRUCTION IN EARLY CHILDHOOD EDUCATION DERIVED FROM DEVELOPMENTAL THEORIES (3)
- 452. ANALYSIS OF MODEL EARLY CHILDHOOD EDUCATION PROGRAMS (3)
- 454. (I.F.S. 454) DEVELOPMENT AND ADMINISTRATION OF CHILD SERVICE PROGRAMS (3)
- 470. WORKSHOP IN SELECTED STUDIES IN CURRICULUM (1-6)
- 471. WORKSHOP IN SELECTED STUDIES IN SUPERVISION (1-6)
- 478. THE YOUNG CHILD'S PLAY AS EDUCATIVE PROCESSES I (3)
- 490. (Human. 490) HUMANITIES FOR TEACHERS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

570. **PROBLEMS SEMINAR FOR EXPERIENCED EDUCATORS (3)** Historical, psychological, social, and economic factors influencing educational programs. Prerequisite: 12 credits in education and psychology.
571. **SEMINAR IN CONTEMPORARY ISSUES IN ELEMENTARY EDUCATION (1-3)** Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisites: 6 credits in elementary education and teaching experience.
572. **ISSUES AND TRENDS IN EARLY CHILDHOOD EDUCATION (3)** Research, experimental programs and emerging trends in early childhood education; relationships between educational experiences and later intellectual and emotional development. Prerequisites: C.&S. 472, Ed.Psy. 400.
573. **ORGANIZATION OF THE ELEMENTARY SCHOOL CURRICULUM (3)** Principles underlying curriculum construction. Primarily for elementary education majors. Prerequisite: C.I. 414 or teaching experience.
575. **ORGANIZATION OF THE SECONDARY SCHOOL CURRICULUM (3)** Functions of laymen, pupils, teachers, supervisors, and administrators in secondary school curriculum construction. Prerequisites: 12 credits in education and psychology, and teaching experience.
576. **CURRICULUM THEORY K-12 (3)** The analysis and use of the foundations which underlie models of curriculum design. Prerequisite: C.&S. 573 or 575.
577. **SEMINAR IN CURRICULUM RESEARCH (3)** Seminar designed to meet the need for special study of particular research projects in elementary and secondary education. Prerequisite: 12 credits of graduate work in education.
578. **STANDARD WORKS IN CURRICULUM AND INSTRUCTION (3)** Study of significant empirical, historical, evaluative, philosophical, and critical works having an impact on curriculum and instruction practice. Prerequisite: C.&S. 576.
580. **SUPERVISION OF STUDENT TEACHERS (3)** A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education including at least 5 in methods.
581. **PRINCIPLES OF INSTRUCTIONAL SUPERVISION (3)** Social and institutional settings for instructional supervision; functions, activities, and practices of supervision; supervisory case studies.
582. **SYSTEMATIC OBSERVATION OF INSTRUCTION (3)** Construction and use of valid and reliable systematic observation systems used as a basis for classroom observation of instruction. Prerequisite: student teaching or teaching experience.
583. **INTERNSHIP IN CURRICULUM AND SUPERVISION (3-6)** Internship in schools or educational facilities where student is not employed, under supervision of graduate faculty in student's major area.
588. **PROBLEMS, PROJECTS, AND AREA STUDIES IN CURRICULUM AND INSTRUCTION (1-6)** Independent work in the study of topics in curriculum and instruction; development of new curricula, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of program chairman.

INDUSTRIAL ARTS EDUCATION (IA ED)

460. **PLANNING AND MANAGEMENT OF INSTRUCTIONAL RESOURCES (3)**
461. **CONSTRUCTION ACTIVITIES IN THE ELEMENTARY SCHOOL (3)**
462. **PROBLEMS IN INDUSTRIAL ARTS (2)**
464. **CURRICULUM AND INSTRUCTION: INDUSTRIAL STUDIES (3)**
465. **PREPROFESSIONAL EXPERIENCE IN INDUSTRIAL STUDIES (1-3)**
496. **INDEPENDENT STUDIES (1-12)**
497. **SPECIAL TOPICS (1-6)**
561. **HISTORY AND PHILOSOPHY OF INDUSTRIAL ARTS (2-3)** Historical developments and concurrent educational philosophies of industrial arts in American education.

562. CURRICULUM DEVELOPMENT IN INDUSTRIAL ARTS EDUCATION (2-3) Analysis of curriculum innovations in industrial arts and cognate fields; strategies for implementing curricular change; construction and assessment of curriculum materials. Prerequisite or concurrent: I.A.Ed. 561. Prerequisite: teaching experience.

563. SUPERVISION AND ADMINISTRATION OF INDUSTRIAL ARTS EDUCATION (2-3) How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisite or concurrent: I.A.Ed. 562. Prerequisite: teaching experience.

564. EVALUATION IN INDUSTRIAL ARTS (2-3) Construction of informal manipulative and written tests; use of standardized mechanical aptitude tests; construction and use of performance rating scales. Prerequisite: C.&S. 400 or 401.

568. RESEARCH IN INDUSTRIAL ARTS (2-3) Research techniques in industrial arts education. Prerequisite or concurrent: C.&S. 400.

569. SEMINAR IN INDUSTRIAL ARTS (1-9) Directed intensive study, investigation or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INSTRUCTIONAL SYSTEMS (INSYS)

411. ORIENTATION TO INSTRUCTIONAL SYSTEMS (2)

412. PRODUCTION AND UTILIZATION OF GRAPHIC STIMULUS MATERIALS (3)

413. PRODUCTION OF EDUCATIONAL MOTION PICTURES (3)

414. TELEVISION IN EDUCATION (3)

415. SYSTEMATIC INSTRUCTIONAL DEVELOPMENT (3)

425. INSTRUCTIONAL SYSTEMS DESIGN I (3)

430. COMPUTERS IN INSTRUCTION (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

511. ORGANIZATION AND ADMINISTRATION OF MEDIA IN SCHOOLS (3) Problems of providing instructional media in schools; the role of the media consultant in curriculum construction. Prerequisite: In.Sys. 411.

525. INSTRUCTIONAL SYSTEMS DESIGN II (3) Advanced rational and empirical methods of analyzing and designing instructional systems. Prerequisites: In.Sys. 425 and a course in research methods.

532. SURVEY OF MEDIA RESEARCH (3) Systematic study of media research in educational applications of television, still and motion pictures, graphic and simulated environments. Prerequisite: Ed.Psy. 400.

MATHEMATICS EDUCATION (MTHED)

410. TEACHING SECONDARY MATHEMATICS I (1)

411. TEACHING SECONDARY MATHEMATICS II (2)

412. TEACHING SECONDARY MATHEMATICS III (3)

420. TEACHING MATHEMATICS IN THE ELEMENTARY SCHOOLS (3)

422. INDIVIDUALIZING INSTRUCTION IN SCHOOL MATHEMATICS (3)

424. CONTEMPORARY ELEMENTARY SCHOOL MATHEMATICS PROGRAMS (3)

425. CONTEMPORARY SECONDARY SCHOOL MATHEMATICS PROGRAMS (3)

427. COMPUTERS AND THE TEACHING OF MATHEMATICS (3)

470. SELECTED STUDIES IN MATHEMATICS EDUCATION (1-6)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

520. ANALYSIS OF RESEARCH IN MATHEMATICS EDUCATION (3) Survey of the status of knowledge about mathematics learning and instruction, K-12; analysis of research procedures; instruments for evaluating research. Prerequisites: Mth.Ed. 420 or 412, 3 credits in statistics, and teaching experience.

521. **STRATEGIES FOR RESEARCH IN MATHEMATICS EDUCATION (3)** In-depth analysis of strategies for research in mathematics education; conditions for applying the scientific model; implications for research and development. Prerequisite: Mth.Ed. 520.

525. **RESEARCH PARTICIPATION IN SCHOOL MATHEMATICS CURRICULUM CONSTRUCTION (3)** Development of theoretical bases for the construction of instructional materials in mathematics, research participation in preparing and testing curriculum materials. Prerequisite: Mth.Ed. 521.

READING, COMMUNICATION, AND LANGUAGE EDUCATION (RCLED)

400. **TEACHING READING IN THE ELEMENTARY SCHOOL (3)**

401. **METHODS OF TEACHING LANGUAGE ARTS IN ELEMENTARY SCHOOL (3)**

402. **TEACHING CHILDREN'S LITERATURE (3)**

410. **TEACHING SECONDARY ENGLISH I (1)**

411. **TEACHING SECONDARY ENGLISH II (2)**

412. **TEACHING SECONDARY ENGLISH III (3)**

420. **TEACHING READING AND LITERATURE TO ADOLESCENTS (3)**

424. **SEMINAR IN FOREIGN LANGUAGE AND BILINGUAL EDUCATION (3)**

440. **FUNDAMENTALS OF READING INSTRUCTION (3)**

442. **THE ELEMENTARY SCHOOL LANGUAGE ARTS PROGRAM (3)**

443. **TEACHING LANGUAGE AND COMPOSITION (3)**

445. **TEACHING ENGLISH IN BILINGUAL/DIALECTAL EDUCATION (3)**

446. **REMEDIAL READING IN THE CLASSROOM (3)**

450. **CONTENT AREA READING (3)**

467. **INTERGROUP STORYTELLING (3)**

470. **SELECTED STUDIES IN READING, COMMUNICATION, AND LANGUAGE EDUCATION (1-6)**

496. **INDEPENDENT STUDIES (1-12)**

497. **SPECIAL TOPICS (1-6)**

526. (Ed.Psy. 526) **THE PSYCHOLOGY OF READING (3)** Psychological principles underlying the process of reading and comprehending with application to instruction. Prerequisite: Ed.Psy. 421.

540. **TEACHING READING: LINGUISTICS PERSPECTIVE (3)** Examination of reading as language and thought processes; contributions of linguistics, orthography, semantics, and syntax to instructional strategies. Prerequisites: undergraduate reading course and teaching experience.

541. **CHILDREN'S LITERATURE RELATED TO ETHNIC AND SOCIAL ISSUES (3)** Children's literature, K-12; study of literary symbolism, ethnic literature, and controversial issues; bibliotherapy, censorship, sex education through the trade book. Prerequisite: RCLEd. 402.

542. **ISSUES IN READING, COMMUNICATION, AND LANGUAGE EDUCATION (3 per term, maximum of 6)** Issues in curriculum development and research in reading, communication, and language education, K-12, instructional materials analysis, and development. Prerequisites: RCLEd. 412; and teaching experience.

543. **RESEARCH IN THE TEACHING OF READING, COMMUNICATION, AND LANGUAGE EDUCATION (3 per term, maximum of 6)** Cooperative study of problems and research findings in the teaching of reading, communication, and language education in American schools. Prerequisite: RCLEd. 412; and teaching experience.

545. **DIAGNOSTIC TESTING IN READING (3)** Practicum in diagnosing reading difficulties, elementary and secondary levels; achievement, diagnostic, and capacity tests; informal inventories; genesis of reading problems. Prerequisite: RCLEd. 440.

550. **THEORY AND PRACTICUM IN REMEDIAL READING FOR ELEMENTARY STUDENTS (3)** Supervised practicum with young children where remediation designs are analyzed, applied, and evaluated. Prerequisites: RCLEd. 440 or equivalent teaching experience, and RCLEd. 545.

551. **THEORY AND PRACTICUM IN REMEDIAL READING FOR SECONDARY/ADULT LEARNERS (3)** Supervised practicum work with secondary/adult/remedial students based upon theories and research concerning the reading problems of young adults. Prerequisite: RCLEd. 550.

557. **PRACTICUM: REMEDIAL PROCEDURES AND DIAGNOSIS (3-6)** Advanced practicum; diagnostic testing and remedial instruction of more severe types of reading disability; newer and special materials and procedures. Prerequisite: RCLEd. 545.

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

SCIENCE EDUCATION (SCIED)

410. **TEACHING SECONDARY SCIENCE I (1)**

411. **TEACHING SECONDARY SCIENCE II (2)**

412. **TEACHING SECONDARY SCIENCE III (3)**

454. **SCIENCE IN EARLY CHILDHOOD EDUCATION (3)**

455. **FIELD NATURAL HISTORY FOR TEACHERS (3)**

456. **TEACHING OF CONSERVATION OF NATURAL RESOURCES IN THE SCHOOLS (3)**

457. **TEACHING OF ENVIRONMENTAL EDUCATION IN THE SCHOOLS (3)**

458. **TEACHING SCIENCE IN THE ELEMENTARY SCHOOL (3)**

470. **SELECTED STUDIES IN SCIENCE EDUCATION (1-6)**

496. **INDEPENDENT STUDIES (1-12)**

497. **SPECIAL TOPICS (1-6)**

556. **THE SUPERVISION OF SCIENCE CURRICULUM (3)** Supervision of elementary and secondary science teachers as they develop K-12 programs in the public schools. Prerequisites: 6 credits in science methods, 20 credits in science or equivalent, and teaching experience.

557. **(Biol. 557) WORKSHOP IN THE BIOLOGICAL SCIENCES (3)** Projects designed for teachers of biology in the secondary schools.

558. **RESEARCH PROBLEMS IN SCIENCE TEACHING (3)** Problems and research dealing with curriculum, materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sci.Ed. 412 or 458, and teaching experience.

559. **ANALYSIS OF INSTRUCTION IN ELEMENTARY SCIENCE EDUCATION (3)** Analysis of the history, issues, trends, and research in elementary science education. Prerequisites: teaching experience, 3 credits in elementary science methods, and 18 credits of science courses.

SOCIAL STUDIES EDUCATION (SS ED)

410. **TEACHING SECONDARY SOCIAL STUDIES I (1)**

411. **TEACHING SECONDARY SOCIAL STUDIES II (2)**

412. **TEACHING SECONDARY SOCIAL STUDIES III (3)**

430. **TEACHING SOCIAL STUDIES IN THE ELEMENTARY GRADES (2-3)**

432. **THE SOCIAL SCIENCES IN THE SOCIAL STUDIES CURRICULUM (2-3)**

470. **ISSUES IN SOCIAL STUDIES EDUCATION (1-6)**

496. **INDEPENDENT STUDIES (1-12)**

497. **SPECIAL TOPICS (1-6)**

530. **INSTRUCTIONAL PRACTICES IN THE SOCIAL STUDIES (3)** Social studies innovations in the classroom, new programs, new materials, new methods, and evaluation. Prerequisite: one year of teaching experience.

533. **RESEARCH IN THE TEACHING OF SOCIAL STUDIES (3)** Procedures and methods of research for the teaching of social studies, strategies of investigation and review of research literature. Prerequisites: 12 credits in the social sciences on the 400 or 500 level and teaching experience.

DAIRY SCIENCE (D SC)

E. M. KESLER, *Chairman, Graduate Program in Dairy Science*
205 Borland Laboratory
814-865-7638

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Almquist, Baumgardt, Flipse, Hargrove, Kesler, McCarthy, Muller, Patton, and Tanabe.

Graduate Faculty: Associate Members Shellenberger, Specht, and Thoele.

Students may specialize in dairy cattle nutrition, metabolism, dairy cattle genetics, dairy cattle management, and physiology of reproduction. A minor program generally is taken in agricultural economics, animal nutrition, biochemistry, genetics, physiology, or statistics. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language or communication skills.

Prerequisite to graduate work is the completion of an undergraduate major in animal industry, animal science, dairy science, or a related area. The undergraduate program must include mathematics and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests. The Graduate Record Examination is required of all applicants.

DAIRY SCIENCE (D SC)

- 410. DAIRY HERD MANAGEMENT (4) *Muller*
- 423. ADVANCED DAIRY CATTLE JUDGING (1 per term, maximum of 2)
- 427. MILK SECRETION (3) *Kesler*
- 431. PHYSIOLOGY OF REPRODUCTION IN FARM ANIMALS (3)
- 490. COLLOQUIUM (1)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 507. DAIRY CATTLE MANAGEMENT (1-6)
- 511. DAIRY CATTLE NUTRITION (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr.
- 401. *Kesler*
- 512. ADVANCED STUDIES IN MILK SECRETION (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Kesler*
- 513. DAIRY CATTLE BREEDING (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: An.Sc. 322, Biol. 422, 3 credits in statistics. *Hargrove*
- 515. ADVANCED PHYSIOLOGY OF REPRODUCTION IN FARM ANIMALS (1-6) *Almquist*
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

DEVELOPMENTAL AND REMEDIAL READING (D R R)

CAROL A. CARTWRIGHT, *In Charge of Graduate Program in Developmental and Remedial Reading*
155 Chambers Building
814-865-5433

Degree Conferred: M.Ed.

Graduate Faculty: Senior Members Askov, Bliesmer, Cartwright, M. Dupuis, Fagan, Golub, Heilman, and Madsen.

The purpose of the master's program is to prepare classroom teachers in elementary and secondary schools for more effective teaching of reading and to provide preparation for supervisory and administrative positions relative to reading in school systems.

Candidates for a master's degree must meet the requirements for admission to graduate study and, in addition, (1) must hold, or be eligible to hold, a valid teaching certificate (persons not meeting this criterion may work on overcoming deficiencies; graduate credit, but not degree credit, may be received for graduate courses taken to overcome such deficiencies) and (2) must have had at least one year of teaching experience or the equivalent.

The master's program has been planned so that those completing the program will also meet the state requirements for "reading specialist" certification.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Detailed descriptions of courses available in reading may be found under Reading, Communication, and Language Education: RCLEd. 405, 420, 440, 446, 450, 526, 540, 545, 550, 551, 557, 596, 597.

EARTH SCIENCES (EARTH)

CHARLES THORNTON, *In Charge of Graduate Program in Earth Sciences*
539 Deike Building
814-865-4462

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Blackadar, Cuffey, Dachille, de Pena, Dutton, Hosler, Lavin, Lewis, Panofsky, Thomson, Thornton, Traverse, Wernstedt, Williams, and Wright.

Graduate Faculty: Associate Members Cahir, Olivero, and J. Pena.

The M.Ed. program is designed to meet the needs of science teachers in elementary and secondary schools. The earth science fields of study are geography, geological sciences (geology, geochemistry and mineralogy, or geophysics), and meteorology. The student selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a paper in that area. An additional 12 credits must be taken in the other two fields of earth sciences; or 6 credits may be taken in one of the earth science fields plus 6 credits in other science or engineering fields. Two education courses, C.&S. 400 and Sci.Ed. 558, are required as a minor.

Students with a 2.50 junior-senior average, 18 credits in education and related psychology, and 6 credits in earth science fields or other appropriate background will be considered for admission to the M.Ed. program. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. The M.Ed. program is not offered during the summer term.

The D.Ed. program is designed for secondary school and college science teachers. The course requirements are planned by the candidate's committee. A minimum of 60 credits must include one area of concentration within the earth sciences — geography, geological sciences (geology, geochemistry

and mineralogy, or geophysics), or meteorology — plus courses from each of the other two earth science areas. A minimum of 15 credits each is required in professional education and in thesis research. The thesis topic must be in one of the earth sciences. Three consecutive terms of residence are required for the D.Ed. degree. The student's D.Ed. committee shall normally consist of five members — two members from the area of concentration, one member from each of the other two earth science fields, and one member from education.

In order to enter the D.Ed. program a candidate should present evidence of competence at the baccalaureate level in one of the earth sciences (geography, geological sciences, or meteorology) or in an allied science curriculum. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.70 grade-point average will be made for students with special backgrounds, abilities, and interests.

EARTH SCIENCES (EARTH)

400. EARTH SCIENCES SEMINAR (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

500. EARTH SCIENCES RESEARCH (1-6) Relationships between the earth sciences revealed by theory, analytical methods, or a selected problem.

ECOLOGY (ECLGY)

EDWARD D. BELLIS, *In Charge of Graduate Programs in Ecology*

311 Erwin W. Mueller Building

814-865-1556

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baker, Bellis, Butler, Card, Cooper, Cuffey, Davis, DeWalle, Dunson, George, Graves, Guber, Hower, Hutnik, Keener, Kim, MacCluer, Patil, Rothenbacher, Schein, Shipman, Unz, and F. Williams.

Graduate Faculty: Associate Members Arnold, Burris, Kurland, Pearson, and Stephenson.

This intercollege program emphasizes the properties of ecosystems by focusing attention on interactions of single organisms, populations, and communities with their environment. It is designed to give students a basic understanding of ecological theory and is, therefore, complementary to other environmental programs which emphasize man's role in ecosystems.

The instructional program includes three graduate core courses in ecology, augmented by an additional integrated group of seminars and courses selected for each student by the committee, and a research project directed by the thesis adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. The nonthesis option is available for the M.S. degree, upon adviser discretion.

The program is administered by a committee drawn from faculty members in several departments and colleges of the University. This committee and its chairman are appointed by the dean of the Graduate School. The instructional staff is composed of participating faculty in those departments offering graduate courses in fields closely allied to ecology.

The committee appointed by the Graduate School for each candidate in ecology is selected from members of the program committee and faculty from the student's area of specialization. The committee has the responsibility for determining the course program and research acceptable in satisfying degree requirements.

Students meeting the admission requirements of the Graduate School will be considered up to the number of spaces available in selecting candidates in this program. Candidates should have a strong science background including chemistry, physics, and mathematics. Preparation in biological sciences

is also desirable. Students with a unique background in another discipline which has potential value to original ecological work will be seriously considered.

Students are strongly urged to choose their research interests and initiate communication with the relevant faculty member(s) before applying for admission. This is especially crucial if the student is seeking financial aid. Teaching and research assistantships are available only through the student's faculty adviser.

In addition to the formal application, the applicant should forward the following *directly to the program chairman*: (1) two or more letters of recommendation regarding the student's academic and professional promise; (2) a concise one-page statement describing the student's goals both within the program and in professional life; and (3) Graduate Record Examination scores including verbal, quantitative, and an advanced test. More specific inquiries may be directed to the program chairman.

Detailed descriptions of courses now available for students majoring in ecology may be found under the offerings of several departments: Anthy. 502, 523; Biol. 433, 434, 435, 436, 451, 480, 481, 516, 519, 544, 545, 546; C.E. 472, 579, 580; Cmp.Sc. 402; Ent. 416, 517, 535; E.R.M. 410, 413; For. 508, 517; Geol. 503; Geosc. 425, 426, 547; Meteo. 505; Micrb. 400, 413, 529; Phil. 512; P.Path. 424; Stat. 524; V.Sc. 401; Wildl. 446, 551.

ECOLOGŸ (ECLGY)

590. COLLOQUIUM (1-3)

ECONOMICS (ECON)

MONROE NEWMAN, *Head of the Department*

613 Kern Graduate Building

814-865-1456

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Senior Members Budd, Farr, Feller, Herendeen, Hu, Klein, Lombra, Nelson, Newman, Prybyla, Riew, Robinson, Rodgers, and Rozen.

Graduate Faculty: Associate Members Benson, Dickinson, Feinberg, Fox, Friedrich, Hartigan, Mehra, Ott, Rosenberg, Stephenson, Wasylenko, Wentzler, and Witte.

Opportunities are available for concentration in the following fields: economic analysis, economic doctrines, economic development of developed areas, economic development of underdeveloped areas, economic fluctuations, income distribution, industrial organization, international economics, comparative economic systems, labor economics, money and banking, public finance, quantitative economics, statistics, and regional economics.

Students may also qualify for admission to the program in population issues, consisting of interdisciplinary course work with special emphasis on the economic, social, and geographic issues arising from the dynamics of population change.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by any of the following alternatives: (1) a reading knowledge of two foreign languages, (2) a reading knowledge of one foreign language and 6 credits of other course work from designated areas which increase research skills, (3) the equivalent of 12 credits of departmentally approved course work which increases research skills, or (4) a comprehensive knowledge of one foreign language. The nonthesis option is available for the M.A. degree; a student choosing the program option in operations research must complete a thesis.

To enter graduate work in economics a student should have completed at least 18 undergraduate credits in the fields of economics, accounting, commerce, and business statistics, including at least 6 credits in economics. All applicants must take the Graduate Record Examination in advanced economics and general aptitude.

Students with a 2.50 junior-senior average, a 3.00 average in courses in economics, and appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up

to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.A. degrees (see p. 239).

ECONOMICS (ECON)

- 400. HISTORY OF ECONOMIC THOUGHT I (3)
- 401. HISTORY OF ECONOMIC THOUGHT II (3)
- 404. CURRENT ECONOMIC ISSUES (3)
- 405. ADVANCED ECONOMIC ANALYSIS (3)
- 412. LABOR MARKETS AND COLLECTIVE BARGAINING (3)
- 413. (L.S.413) COMPARATIVE LABOR MOVEMENTS (3)
- 414. (L.S.414) THEORIES OF THE LABOR MOVEMENT (3)
- 415. ECONOMICS OF INCOME MAINTENANCE (3)
- 423. STATE AND LOCAL TAXATION (3)
- 424. URBAN ECONOMICS (3)
- 425. ECONOMICS OF PUBLIC EXPENDITURES (3)
- 427. (Ed.Adm. 427) ECONOMICS OF EDUCATION (3)
- 428. ENVIRONMENTAL ECONOMICS (3)
- 429. ADVANCED PUBLIC FINANCE (3)
- 433. INTERNATIONAL MONETARY ECONOMICS (3)
- 442. MONOPOLY, COMPETITION, AND THEIR REGULATION (3)
- 445. (H.P.A. 445) HEALTH ECONOMICS (3)
- 450. THE BUSINESS CYCLE (3)
- 451. MONETARY THEORY AND POLICY (3)
- 462. ECONOMIC GROWTH: THEORIES OF UNITED STATES DEVELOPMENT (3)
- 463. ECONOMIC DEMOGRAPHY (3)
- 480. MATHEMATICAL ECONOMICS (3)
- 489. HONORS THESIS (3-6)
- 490. INTRODUCTION TO ECONOMETRICS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 499. FOREIGN STUDY IN ECONOMICS (2-6)
- 500. ECONOMIC SEMINAR (3-6)
- 502. MICROECONOMIC ANALYSIS (3) Economic behavior under pure and imperfect competition; price and output determination in product markets; prices and employment in factor markets.
- 503. MACROECONOMIC ANALYSIS (3) National income accounts; determination of income, employment, interest rates, and the price level; stabilization policy.
- 506. PROBLEMS IN ECONOMICS (1-12) Planned projects involving library, laboratory, or field work.
- 507. INTERNATIONAL TRADE (3) A survey of international trade theory including modern developments of pure theory, and of international trade policy.
- 508. CURRENT MONETARY THEORY AND POLICY (3) Post-Keynesian reformulation of quantity and Keynesian theories of money; liquidity and general equilibrium approaches; current issues in theory and policy.
- 510. ECONOMETRICS (3-6) Statistical estimation in mathematically formulated economic relationships.
- 513. DEVELOPMENT OF ECONOMIC DOCTRINES (3-6)
- 515. ECONOMICS OF THE LABOR MARKET (3) Theory and problems of labor-management relations; selected problems of the labor market with reference to current research and developments.
- 516. ECONOMICS OF HUMAN RESOURCES (3) Analysis of changes in human resource supply and demand; factors affecting these changes; current human resource policies.

517. INTERNATIONAL FINANCE (3) Problems of international liquidity; balance of payments adjustment; international financial institutions and selected policy problems.
518. DEVELOPMENT OF MONETARY THEORY (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.
519. (Mn.Ec. 519) MINERAL POLICY ANALYSIS (3) Principles of policy analysis; cost-benefit and other analytical techniques; environmental analyses; case studies of legislative and administrative mineral policy issues.
521. ADVANCED MICROECONOMIC THEORY (3-6) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.
522. ADVANCED MACROECONOMIC THEORY (3-6) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.
524. INCOME DISTRIBUTION (3) Measurement of inequality; ethical issues in income redistribution; measurement and determination of distributive shares; problem of poverty.
525. ECONOMICS OF TECHNOLOGICAL CHANGE (3) Theoretical and empirical analysis of invention and innovation and their effects on productivity, employment, and market structure.
529. PUBLIC FINANCE (3-6) Contemporary problems in public finance; instruments of fiscal policy in the achievement of full employment, price stability, and economic development.
530. REGIONAL MICROECONOMICS (3) Theoretical and empirical analysis of industrial location as determined by costs, markets, and agglomeration effects.
531. REGIONAL MACROECONOMICS (3) Aggregate regional trade flows; sources of regional economic data; techniques for measuring regional economic activity; long-run regional growth.
543. INDUSTRIAL ORGANIZATION AND PUBLIC POLICY (3-6) The structure of American industry; performance and behavior; public policies toward business.
550. ECONOMIC FLUCTUATIONS (3) Analysis of the various theories of economic fluctuations; their methodological premises.
551. STABILIZATION POLICY (3) Description and analysis of the alternatives and issues in stabilization policy.
560. SEMINAR IN ECONOMIC GROWTH: UNDERDEVELOPED AREAS (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.
561. SEMINAR IN ECONOMIC GROWTH: DEVELOPED AREAS (3-6) Growth models; strategic factors in growth; quantification problems; public policy.
571. COMPARATIVE ECONOMIC SYSTEMS (3-6) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision making and control.
572. SOVIET AND OTHER CENTRALLY PLANNED ECONOMIES (3-6) Principles, structure, and performance of centrally planned economies with special emphasis on the Soviet Union.
580. MATHEMATICAL ECONOMICS (3-9) Mathematical development of static and dynamic economic models; partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: Econ. 480.
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

EDUCATIONAL ADMINISTRATION (EDADM)

PATRICK D. LYNCH, *In Charge of Graduate Programs in Educational Administration*
318 Rackley Building
814-865-1487

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Caldwell, Johnson, Lutz, Lynch, and Willower.

Graduate Faculty: Associate Members Fraser, Gipp, and Noley.

Professional preparation programs are offered at the master's and doctoral degree levels for elementary and secondary school personnel whose objectives are to become prepared in education policy-making positions such as principals, supervisors, superintendents, intermediate unit officials, state and federal education agency personnel, professors of educational administration, or researchers in educational administration.

All candidates who seek M.Ed. and M.S. degrees in educational administration shall complete programs embracing a minimum of 30 graduate credits. Only in rare instances, however, to fulfill unusual objectives, will candidates be permitted to work toward the M.S. degree. In Pennsylvania a certification program consisting of at least 45 credits is required before one can become a public school administrator. Courses may be taken at the Capitol Campus; however, admission to the M.Ed. program must be approved by the University Park program chairman.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign and native American languages.

Candidates for the Ph.D. degree are required to complete a minimum of three consecutive terms during a calendar year in residence, but are strongly advised to spend two academic years in residence. Candidates for the D.Ed. must spend three out of any four terms in residence.

From the time of initiation of a 600-level thesis research program, all doctoral candidates shall continuously register (at least three terms per calendar year) until the termination of the graduate program. Failure to register for doctoral thesis credits in three out of four terms shall be considered automatic withdrawal. Specific requirements with respect to the Ph.D. and D.Ed. degrees may be learned from a departmental bulletin that is available upon request and from additional information in this catalog. Although candidates are required to specialize in a field of educational administration, they are encouraged to acquire a background in the social sciences and the humanistic foundations.

Requirements for admission to a graduate program in educational administration ordinarily include 18 approved undergraduate credits in education and psychology. All applicants for any graduate program, including certification, must submit either a Miller Analogies Test or Graduate Record Examination (quantitative and verbal) score. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Students with a 2.60 junior-senior average (on a scale of 4.00) and with appropriate course backgrounds will be considered for admission to a master's program. Exceptions to the minimum 2.60 grade-point average may be made for students with special backgrounds, abilities, and interests. Those entering doctoral programs are required to have a grade-point average of 3.50 (on a scale of 4.00) in prior graduate work.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 239).

EDUCATIONAL ADMINISTRATION (EDADM)

- 427. (Econ. 427) ECONOMICS OF EDUCATION (3)
- 460. (Hi.Ed. 460) INTRODUCTION TO ADULT EDUCATION (3)
- 480. EDUCATIONAL ADMINISTRATION (2-3)
- 481. COLLECTIVE NEGOTIATIONS IN PUBLIC EDUCATION (3)

525. FEDERAL EDUCATION POLICIES (3) Analysis of federal role in development of educational policy and its relationship to state and local policy.

528. **POLITICS AND EDUCATION (3)** Social forces which shape the educational system and determine national, state, and local educational policies.
533. **THE POLITICS OF LOCAL SCHOOL DISTRICTS (3)** The methodology of studying political decision making and the theory and practice of politics in local school districts. Prerequisite: 6 credits of sociology, anthropology, or political science.
560. **SYSTEM THEORY IN EDUCATION (3)** Concepts of general system theory, the systems approach, and related methodologies and tools; applications in education; critique of instructional systems. Prerequisites: Ed.Psy. 400, 475.
565. **PERSONNEL AND GRIEVANCE ADMINISTRATION (2-3)** Practice and theory of personnel supervision at the central office and building level, including contract administration and grievance handling. Prerequisites: 18 credits in education and three years' teaching experience.
567. **ORGANIZATIONAL SUPERVISION (3)** The organizational context of the school, its relationship to supervision, and the improvement of instruction. Prerequisites: Ed.Adm. 480 and teaching experience.
568. **THE PRINCIPALSHIP (2-3)** For elementary and secondary principals. The administrative and management tasks of building administration. The social system, change, and community relationships.
569. **PRINCIPALSHIP SEMINAR (2-3)** The study and application of interdisciplinary-based products and processes in the various organizational units within the educational system.
571. **THE EDUCATIONAL PLANT (2-3)** School plant needs in terms of school population and curriculums; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventilation, equipment, school building costs and finance. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
572. **ANALYSIS OF SCHOOL-COMMUNITY RELATIONS (2-3)** School-community relationships; social structure, social change, and the schools; case studies of community-school problems. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
573. **PUBLIC SCHOOL FINANCE (2-3)** Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money management. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
574. **THEORY AND PRACTICE OF EDUCATIONAL NEGOTIATIONS (2-3)** Theoretical framework, bargaining strategies, legislation, administrative roles, agreements, etc. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience, and previous work in school administration.
575. **(Hi.Ed. 575) ADMINISTRATION OF ADULT EDUCATION (3)** The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
576. **LEGAL ASPECTS OF SCHOOL ADMINISTRATION (3)** Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies, the course of study, textbooks; contracts; taxes, torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
577. **ECONOMIC DIMENSIONS OF EDUCATIONAL ADMINISTRATION (3)** Application of selected economic concepts and tools of analysis to administrative decision and planning processes in educational systems. Prerequisite: Ed.Adm. 480.
578. **SCHOOLS AS ORGANIZATIONS (2-3)** Intraorganizational relationships; administration and the school as a social system; formal and informal organization. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.
579. **PUBLIC SCHOOL BUSINESS ADMINISTRATION (2-3)** Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria

management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience; Ed.Adm. 573.

580. **THE USE OF THEORY IN EDUCATIONAL ADMINISTRATION (1-6)** Administrative theories applied to educational organizations. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.

581. **FIELD RESEARCH IN EDUCATIONAL ADMINISTRATION (2-3)** The use of field study methods in educational research and evaluation, and of participant observation in administration practice. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.

582. **INTERNSHIP IN ADMINISTRATION AND SUPERVISION (1-12)** Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

583. **SUBSTANTIVE ISSUES IN SCHOOL LAW (3)** Focuses on substantive law in such areas as academic freedom, student records, teacher rights and responsibilities, and desegregation. Prerequisite: Ed.Adm. 576.

588. **WORKSHOP IN CURRENT EDUCATIONAL PROBLEMS (1-6)** For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

589. **PROBLEMS, PROJECTS, AND AREA STUDIES IN EDUCATIONAL ADMINISTRATION (1-6)** Independent work in the study of topics in educational administration, or development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

591. **SEMINAR IN PUBLIC SCHOOL RESEARCH (1-4)** Doctoral candidates present outlines of their theses to the graduate faculty of the department and advanced graduate students.

596. **INDIVIDUAL STUDIES (1-6)**

EDUCATIONAL PSYCHOLOGY (EDPSY)

JOSEPH FRENCH, *In Charge of Graduate Programs in Educational Psychology*
403 Carpenter Building
814-865-8303

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members DiVesta, French, Games, Marks, Mitzel, Rabinowitz, Roberts, Schwartz, Seibel, Thevaos, Tjosvold, Weener, and Withall.

Graduate Faculty: Associate Member Snyder.

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in school learning, educational and psychological measurement, statistics and research design as applied to education, and the evaluation of educational programs. There are two options in the master's program. A thesis option is available in any of the above areas, and the M.S. without thesis may be taken in learning or evaluation by teachers, counselors, administrators, parents, and others concerned with intervention strategies or evaluation of education programs. The M.S. with thesis is required for Ph.D. candidates. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, school psychology, and special education, are offered in other departments of the University.

Doctoral degree requirements include a major emphasis in one of the above areas of educational psychology with minor emphasis in one other related area. The doctoral program of study includes a minimum of one course in each of the following areas: individual differences, psychological tests and measurement, statistics, experimental design, and learning from within the program; at least one course in developmental psychology, social psychology, and personality from the Department of Psychology;

and at least one course in educational or philosophical foundations. In lieu of the foreign language requirement for the Ph.D. degree, students are expected to present to the committee a statement of objectives and goals and a plan of the academic and nonacademic work to be undertaken in achieving these goals. Within the context of the above, the students are expected to incorporate relevant experiences which are now part of the language and communication requirements, whether in course work, research, or teaching, to increase their effectiveness as educational psychologists.

Special facilities available to the department include a research design laboratory, rooms for conducting research projects, facilities for film production and editing, and a closed-circuit television studio used for both research and instruction. Other facilities available to students majoring in educational psychology are the Nursery School, the Psychology Clinic, the Reading Center, the Center for Educational Diagnosis and Remediation, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with several computer systems, is available for use in graduate student research.

Students with a 3.00 junior-senior average and a broad undergraduate background including some college mathematics will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants are required to submit scores on the Graduate Record Examination. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one-half of their graduate credits of A quality.

EDUCATIONAL PSYCHOLOGY (EDPSY)

- 400. INTRODUCTION TO STATISTICS IN EDUCATIONAL RESEARCH (3)
- 406. APPLIED STATISTICAL INFERENCE FOR THE BEHAVIORAL SCIENCES (3)
- 421. LEARNING PROCESSES IN RELATION TO EDUCATIONAL PRACTICES (3)
- 450. (Psy. 450) PRINCIPLES OF MEASUREMENT (3)
- 451. APPRAISAL AND INTERPRETATION OF STANDARDIZED GROUP TESTS (2)
- 475. INTRODUCTION TO EDUCATIONAL RESEARCH (2)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

506. ADVANCED TECHNIQUES FOR ANALYZING EDUCATIONAL EXPERIMENTS (3) Analytical and experimental control considerations for designs involving nested and/or crossed subjects. Analysis of variance and multiple comparisons via computers. Prerequisite: Ed.Psy. 406 or Psy. 415.

507. MULTIVARIATE PROCEDURES IN EDUCATIONAL RESEARCH (3) Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisite: Ed.Psy. 406 or Psy. 415.

512. GROUP PROCESSES IN THE CLASSROOM (2) Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.

513. INDIVIDUAL AND GROUP DIFFERENCES (2) Historical and contemporary attempts to relate individual differences to important social and educational issues. Prerequisite: Ed.Psy. 400 or Psy. 15.

518. CONTEMPORARY LEARNING MODELS IN EDUCATIONAL PSYCHOLOGY (3) Contemporary mathematical models and computer simulations of complex human learning occurring in school settings. Modes for analyzing the learning environment. Prerequisite: Ed.Psy. 421.

519. PSYCHOLOGICAL FOUNDATIONS FOR COLLEGE TEACHING (2) Psychological, sociological, and organizational variables which influence college student behavior. Designed for graduate students who anticipate careers in college teaching.

522. CONCEPT LEARNING IN THE SCHOOLS (2) Study of theory and research related to concept formation and attainment with implications for instruction. Prerequisite: Ed.Psy. 421.

523. PROBLEM SOLVING IN THE SCHOOLS (2) Examination of theory and research related to cognitive processes in problem solving with implications for educational practice. Prerequisite: Ed.Psy. 421.

524. THEORIES OF LEARNING AND INSTRUCTION (3) Study of major classical theories of learning and recent developments in learning and instructional theory. Prerequisite: Ed.Psy. 421.
526. (RCLEd.526) THE PSYCHOLOGY OF READING (3) Psychological principles underlying the process of reading and comprehending with application to instruction. Prerequisite: Ed. Psy. 421.
550. DESIGN AND CONSTRUCTION OF PSYCHOLOGICAL MEASURES (3) Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive validity. Prerequisite: Ed.Psy. 450.
554. THEORIES OF PSYCHOLOGICAL MEASUREMENT (2) Basic true-score and error models; their extensions to test reliability and test validity; problems of item analysis and weighting. Prerequisite: Ed.Psy. 450.
575. SEMINAR IN EDUCATIONAL PSYCHOLOGY (3-9) A seminar dealing with specific topics in educational psychology. Open to advanced students in the behavioral sciences.
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

ELECTRICAL ENGINEERING (E E)

DALE M. GRIMES, *Head of the Department*
118 Electrical Engineering East
814-865-7667

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Adams, Brown, Cross, Das, Etzweiler, Ferraro, Fonash, Geselowitz, Grimes, Hale, Lachs, Lee, Lewis, McMurtry, Mentzer, Nisbet, Robinson, Ross, Stach, and Trutt.

Graduate Faculty: Associate Members Carpenter, Delansky, Hulina, Kerr, Monkowski, Stein, and Symons.

The principal areas of graduate research are in ionospheric studies, solid state electronics, computers and digital systems, power systems, and electromagnetics. Course offerings support these research areas, as well as work in automatic control, biomedical engineering, communications, network and system theory, plasmas, and quantum electronics.

For information about areas of specialization, laboratory and research facilities, fellowships, assistantships, and other sources of financial assistance, write directly to the Department of Electrical Engineering, The Pennsylvania State University, University Park, PA 16802.

The Master of Science requirements include the general requirements of the Graduate School as listed under Master's Degrees. Specific Departmental requirements are:

Admission: (a) Satisfactory completion of an undergraduate electrical engineering program at an accredited institution or the equivalent, or (b) satisfactory completion of an undergraduate physics program at The Pennsylvania State University or an equivalent institution, with a minor in electronics. This program requires the participant to take 2 undergraduate courses in addition to the specific course requirements listed below. There are also some restrictions on the electives taken within this program.

Specific Course Requirements: (a) Thesis option — 24 course credits, 6 thesis credits, and a satisfactory thesis; (b) Nonthesis option — 30 course credits, a scholarly report, and a special M.S. exam.

The Doctor of Philosophy requirements include the general requirements of the Graduate School as listed under Doctoral Degrees.

Admission: (a) Satisfactory completion of the M.S. degree requirements in electrical engineering or a closely related field at The Pennsylvania State University or an equivalent institution, or (b) direct admission from the undergraduate program with appropriate undergraduate standing.

Specific Requirements: The communication requirement is met by adequacy in the English language

and computer programming. The candidacy exam consists of both written and oral parts and is the same as the M.S. examination used at The Pennsylvania State University. The comprehensive exam is oral.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D and M.S. degrees (see p. 239).

ELECTRICAL ENGINEERING (E E)

405. ELECTRONIC INSTRUMENTATION FOR NONELECTRICAL ENGINEERS AND SCIENTISTS (3)
 406. ELECTRICAL POWER GENERATION AND TRANSMISSION (3)
 411. PRINCIPLES OF ELECTROMAGNETIC FIELDS (3)
 413. LINEAR NETWORK ANALYSIS (3)
 414. PRINCIPLES AND APPLICATIONS OF LASERS AND MASERS (3)
 415. (Comp.Sc. 415) COMPUTER SYSTEMS ARCHITECTURE (3)
 417. SYSTEM THEORY (3)
 418. SOLID STATE DEVICE TECHNOLOGY (3)
 419. SOLID STATE DEVICES (3)
 423. FUNDAMENTALS OF INDUSTRIAL ELECTRONICS (3)
 424. FUNDAMENTALS OF ELECTRICAL DESIGN (3)
 425. SYMMETRICAL COMPONENTS (3)
 427. DISCRETE-TIME SYSTEMS (3)
 428. LINEAR CONTROL SYSTEMS (3)
 432. UHF AND MICROWAVE ENGINEERING (3)
 438. ANTENNA ENGINEERING (3)
 441. ACTIVE CIRCUITS (3)
 448. LINEAR ELECTRONIC DESIGN (3)
 449. DIGITAL ELECTRONIC DESIGN (3)
 450. NETWORK ANALYSIS (3)
 458. DATA COMMUNICATION (3)
 459. INTRODUCTION TO STATISTICAL THEORY OF COMMUNICATIONS (3)
 461. FUNDAMENTALS OF POWER SYSTEM STABILITY (3)
 470. ELECTRONIC ANALOG COMPUTERS (3)
 471. LOGICAL DESIGN OF SWITCHING SYSTEMS (3)
 472. DIGITAL SYSTEMS (3)
 473. DIGITAL SYSTEMS LABORATORY (3)
 475. INTRODUCTION TO HYBRID COMPUTATION (3)
 477. SYNTHESIS AND DESIGN OF ELECTRICAL SYSTEMS (3)
 490. (Nuc.E. 490) INTRODUCTION TO PLASMAS (3)
 492. (Astro. 492) SPACE ASTRONOMY AND INTRODUCTION TO SPACE SCIENCE (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
-
519. SEMICONDUCTOR DEVICES (3) Characteristics and limitations of bipolar transistors, diodes, transit time and bulk-effect devices. Prerequisite: E.E. 419.
 521. ADVANCED ELECTRICAL ENGINEERING PROBLEMS (1-10)
 527. LINEAR CONTROL SYSTEMS (3) Continuous and discrete-time linear control systems; state variable models; analytical design for deterministic and random inputs; time-varying systems stability. Prerequisites: E.E. 428 or M.E. 455; E.E. 417.
 528. NONLINEAR CONTROL AND STABILITY (3) Design of nonlinear automatic control systems; phase-plane methods; describing functions; optimum switched systems; Liapunov stability; special topics in stability. Prerequisites: E.E. 428 or M.E. 455; E.E. 417.
 529. OPTIMAL CONTROL (3) Variational methods in control system design; classical calculus of variations, dynamic programming, maximum principle; optimal digital control systems; state estimation. Prerequisite: E.E. 527.

530. **ADAPTIVE AND LEARNING SYSTEMS (3)** Adaptive and learning control systems; system identification; performance indices; gradient, stochastic approximation, controlled random search methods; introduction to pattern recognition. Prerequisite: E.E. 527.
535. **ENGINEERING ANALYSIS (3)** Applications of mapping methods, series and integral representations to the solution of boundary value problems in electrical engineering.
540. (Nuc.E. 540) **THEORY OF PLASMA WAVES (3)** Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: E.E. 490.
541. (Nuc.E. 541) **PLASMA THEORY (3)** Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: E.E. 540 (Nuc.E. 540).
546. **FIELD-EFFECT DEVICES (3)** The physical background, characteristics and limitations of surface field-effect and junction field-effect devices and related structures. Prerequisite: E.E. 419.
547. **DIELECTRIC DEVICES (3)** Applications of insulator physics and devices based on insulator properties. Prerequisite: E.E. 419.
548. **LINEAR INTEGRATED CIRCUITS (3)** Design of monolithic, thin-film and hybrid linear integrated circuits; D.C., video, tuned, r.f., and microwave applications. Emphasis on reliability. Prerequisites: E.E. 418, 448.
550. **NETWORK SYNTHESIS (3)** Positive real functions, realizability conditions, synthesis of driving point immittances, synthesis of two-terminal pair networks, transfer function synthesis. Prerequisite: E.E. 450.
560. **STATISTICAL THEORY OF COMMUNICATIONS (3)** Generalized harmonic analysis; the application of correlation and convolution to the detection of signals in noise; various special topics. Prerequisite: E.E. 459 or Math. 409.
561. **INFORMATION THEORY (3)** Mathematical measurement of information; information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems. Prerequisite: E.E. 459 or Math. 409.
562. **DETECTION THEORY (3)** Detection decision theory, Bayes and Neyman-Pearson criteria, optimal receivers, classical estimation theory, signal-noise representations, optimum linear signal parameters estimation. Prerequisite: E.E. 560.
565. **COMPUTER ANALYSIS OF POWER SYSTEMS (3)** Network matrix methods of power system analysis. Formulation and computer solution of short circuit, load flow, and transient stability problems. Prerequisites: Cmp.Sc. 201; E.E. 425 or 461.
569. **SIMULATION OF BIOMEDICAL SYSTEMS (3)** Simulation of biological and medical systems on analog and digital computers; direct electrical analogs; modeling techniques. Prerequisites: E.E. 470; Biol. 11.
570. **ADVANCED ELECTRONIC ANALOG COMPUTERS (3)** Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.
571. **SWITCHING AND SEQUENTIAL MACHINE THEORY (4)** Advanced treatment of switching and machine theory, minimization of machines, state assignment, hazard analysis. Prerequisite: E.E. 472.
572. **DIGITAL SYSTEM DESIGN (3)** Complete digital system design including specification, internal organization, and realization. Discussion of interaction among digital systems and subsystems. Prerequisite: E.E. 472.
573. **FAULT DETECTION IN DIGITAL CIRCUITS (3)** Advanced treatment of fault detection, location and redundancy techniques. Prerequisite: E.E. 472.
580. **RADIO WAVES AND THE IONOSPHERE (3)** The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 62 or 438 or Phys. 557.
581. **CONSTITUTION OF THE IONOSPHERE (3)** Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

ENGINEERING MECHANICS (E MCH)

JOHN R. MENTZER, *Head of the Department of Engineering Science and Mechanics*
227B Hammond Building
814-865-6661

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Conway, Fenlon, Fonash, Hayek, Hu, Kiusalaas, Llorens, Mentzer, Neubert, Queeney, Sharma, Thompson, and Zamrik.

Graduate Faculty: Associate Members Ashok and Pytel.

Graduate programs in engineering mechanics emphasize fundamental knowledge and include research opportunities in theoretical and experimental mechanics, with a primary focus on the mechanics and physics of solids.

Graduate study is available in continuum mechanics, structural mechanics, dynamics, vibrations and acoustics, biomechanics, micromechanics, experimental mechanics, and properties of materials. Thesis work in these areas is frequently directed toward specific applications of technological interest in biosystems, geosystems, energy production and distribution, materials engineering, and structural design.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Programs leading to a minor in engineering mechanics are available for doctoral students who seek to complement their studies in their major fields by acquiring a broader background in theoretical and experimental mechanics.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Other course offerings of the department are listed under *Other Graduate Courses*.

ENGINEERING MECHANICS (E MCH)

- 400. ADVANCED STRENGTH OF MATERIALS AND DESIGN (3) *Hu*
- 401. DESIGN AND SYNTHESIS IN VIBRATIONS (3) *Hayek*
- 402. APPLIED AND EXPERIMENTAL STRESS ANALYSIS (3) *Conway*
- 403. STRENGTH DESIGN IN MATERIALS AND STRUCTURES (4) *Queeney*
- 407. COMPUTER METHODS IN ENGINEERING DESIGN (3) *Kiusalaas*
- 408. ELASTICITY AND ENGINEERING APPLICATIONS (3) *Kiusalaas*
- 409. ADVANCED MECHANICS (3) *Pytel*
- 410. MECHANICS OF SPACE FLIGHT (3) *Pytel*
- 412. EXPERIMENTAL METHODS IN VIBRATIONS (3) *Neubert*
- 415. FRACTURE MECHANICS (3) *Queeney*
- 446. MECHANICS OF VISCOELASTIC MATERIALS (3) *Sharma*
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

500. ADVANCED MECHANICS OF MATERIALS (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-walled cylinders, shrink-fit assemblies, and rotating discs; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13. *Zamrik*

506. EXPERIMENTAL STRESS ANALYSIS (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507. *Conway*

507. **THEORY OF ELASTICITY AND APPLICATIONS (3)** Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13. *Kiusalaas*
509. **THEORY OF PLATES AND SHELLS (3)** Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13. *Kiusalaas*
514. **ENGINEERING MECHANICS SEMINAR (1 per term)** Current literature and special problems in engineering mechanics.
516. **MATHEMATICAL THEORY OF ELASTICITY (3)** Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potential; applications. Prerequisite: E.Mch. 540. *Hayek*
520. **ADVANCED DYNAMICS (3)** Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12; Math. 72 or 431. *Pytel*
521. **STRESS WAVES IN SOLIDS (3)** Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact and numerical methods. Prerequisites: E.Mch. 12; Math. 432 or E.Mch. 524A and 524B.
522. **THEORY OF VIBRATIONS (3)** Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E.Mch. 13; Math. 72 or 431. *Neubert*
524. **MATHEMATICAL METHODS IN ENGINEERING (3 per unit)** *Hayek and Thompson*
- Unit A (3)* Basic tools, including Fourier, Legendre, and other orthogonal series, special functions, Laplace transforms. Applications in mechanics and other fields. Prerequisite: Math. 351.
- Unit B (3)* Solution techniques for boundary-value problems in curvilinear coordinates, integral transforms. Green's functions, potentials, applications to diffusion, vibration, wave-propagation. Prerequisite: E.Mch. 524A or Math. 431.
525. **VIBRATION AND SHOCK IN DAMPED MECHANICAL SYSTEMS (3)** Rubberlike materials; vibration isolation; structural impedance; wave propagation; multiforce excitation of beams; Timoshenko beams; transients; shock spectra; damage; nonlinear response. Prerequisite: E.Mch. 401 or 522.
527. **STRUCTURAL DYNAMICS (3)** Dynamic behavior of structural systems; normal modes; input spectra; finite element representation of frameworks, plates, and shells; impedance; elastic-plastic response. Prerequisites: E.Mch. 12, 13. *Neubert*
528. **EXPERIMENTAL METHODS IN VIBRATIONS (3)** Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, nondestructive testing. Prerequisite: E.Mch. 401 or 522. *Neubert*
530. **SOLID STATE MECHANICS (3)** Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. *Hu*
531. **THEORY OF PLASTICITY AND APPLICATIONS (3)** Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 507. *Hu*
535. (Metal. 535) **CRYSTAL DEFECTS AND MECHANICAL RESPONSE (3)** Mechanical responses of crystalline solids containing point, line, and interfacial defects; elastic and plastic responses. Prerequisite: Metal. 514 or E.Sc. 414. *Queeney*
540. **INTRODUCTION TO CONTINUUM MECHANICS (3)** Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics. *Hayek*
546. **THEORY OF VISCOELASTICITY AND APPLICATIONS (3)** Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E.Mch. 507. *Sharma*

560. FINITE ELEMENT ANALYSIS (3) General theory; application to statics and dynamics of solids, structures, fluids and heat flow; use of existing computer codes. Prerequisites: Cmp.Sc. 201, E.Mch. 13.
570. RANDOM VIBRATIONS IN STRUCTURAL MECHANICS (3) Probability theory applied to random vibrations of linear and nonlinear systems; excitation by ground motion, turbulence, and noise; acoustic damping. Prerequisite: Aersp. 411 or E.Mch. 401 or 522. *Neubert*
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

ENGINEERING SCIENCE (E SC)

JOHN R. MENTZER, *Head of the Department of Engineering Science and Mechanics*
227B Hammond Building
814-865-6661

Degree Conferred: M.S.

Graduate Faculty: Senior Members Conway, Fenlon, Fonash, Hayek, Hu, Kiusalaas, Llorens, Mentzer, Neubert, Queeney, Sharma, Thompson, and Zamrik.

Graduate Faculty: Associate Members Ashok and Pytel.

This program is characterized by strong components in engineering analysis, the basic sciences, and areas of emerging technological importance. The program is interdisciplinary in structure with sufficient flexibility to allow a student to specialize in any of a variety of disciplines according to his or her professional objectives. The basic requirements of course work by subject area are as follows:

Engineering Analysis	— six credits
Materials	— six credits
Basic Sciences	— six credits
Engineering Sciences	— six credits

Within these guidelines, work in the listed areas may be arranged in consultation with the adviser to constitute a program of study to accommodate the objectives of the student, and it is expected that courses outside the department may constitute part of the content in the engineering sciences.

A thesis is required for the M.S. degree as part of the 30 credits required in the program.

Admission to the program requires a bachelor's degree in engineering or science from an accredited institution, with a junior-senior grade-point average of at least 2.50. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

This program should be distinguished from the graduate program in engineering science at Behrend, Capitol, and Radnor which offers the M.Eng. degree.

ENGINEERING SCIENCE (E SC)

400. ELECTROMAGNETIC FIELDS (3)
401. SENIOR DESIGN PROJECT (2)
402. SENIOR DESIGN PROJECT (2)
403. SENIOR DESIGN PROJECT (3)
404. ANALYSIS IN ENGINEERING SCIENCE (3)
405. ENGINEERING APPLICATIONS OF FIELD THEORY (3)
414. ELEMENTS OF MATERIAL SCIENCE (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
501. SOLID STATE ENERGY CONVERSION (3) Principles of solid state energy conversion and their

utilization in engineering devices. Emphasis on current research and development efforts. Prerequisite: E.E. 419 or Phys. 412.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

NOTE: *Other departmental courses are listed under Engineering Mechanics.*

ENGINEERING SCIENCE (E SC)

MATTHEW ROSENSHINE, *Chairman of the Engineering Graduate Committee for Off-Campus Programs*
207 Hammond Building
814-863-2356

Degree Conferred: M.Eng.

Behrend College — Richard C. Bollinger, *Director of Program*

Graduate Faculty: Associate Members Bollinger and Salvia.

Radnor Center for Graduate Studies — Helmut E. Weber, *Director of Program*

Graduate Faculty: Senior Members Callahan, Llorens, and Weber.

Graduate Faculty: Associate Members Duncan, Kozik, and Stein.

Capitol Campus — John S. Wade, Jr., *Director of Program*

Graduate Faculty: Senior Members Bissinger, Cole, Conover, Dahir, Grenier, and Murty.

Graduate Faculty: Associate Members Ezard, Hartzler, Maynard, W. Miller, Przybylski, Rao, Schiller, Shoup, Wade, and Welsh.

A program leading to the degree of Master of Engineering with a major in engineering science is offered at Behrend College, the Radnor Center for Graduate Studies, and at the Capitol Campus, near Harrisburg. Details of the program may be obtained by writing directly to these locations. Addresses are given in the front of this catalog.

The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of the student's major interest. It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area. Courses offered for the program are all established and controlled by the resident departments at the University Park Campus.

This program should be distinguished from the graduate program in engineering science at University Park which offers the M.S. degree.

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering which have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 30 credits is required, of which at least 12 must be at the 500 level. A scholarly written report is also required. Three of the above credits may be applied to this report.

Students may be admitted to the program from a wide variety of disciplines. Students applying for admission are expected to have completed the following core of courses: (1) physics through modern physics, (2) mathematics through differential equations, (3) one course in engineering thermodynamics, (4) one course in electrical circuits, and (5) basic courses in engineering statics and dynamics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details regarding admission requirements are available from the directors of the graduate centers offering the program.

ENGLISH (ENGL)

WENDELL V. HARRIS, *Head of the Department*

117 Burrowes Building

814-865-6381

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Arnold, Austin, Begnal, Borklund, Condee, Crane, Damerst, Harris, Hudspeth, R. Hume, Joukovsky, Kiernan, Lewis, Lougy, Mann, Meserole, O'Donnell, Price, Rodgers, R. Secor, Smith, Walden, S. Weintraub, West, and Young.

Graduate Faculty: Associate Members Balaban, Buck, Buckalew, Burns, Ebbitt, Eckhardt, Fitzgerald, Gidez, Grecco, K. Hume, Kiffer, McAdams, Moore, Rambeau, Rogers, Schneeman, Thigpen, Toth, and Trautmann.

A student may specialize in English literature, American literature, or philology. A student may also specialize in writing, with a concentration in poetry, fiction, nonfiction, editing, or business and technical writing. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If the student does not present 18 credits in English, deficiencies must be made up early in the graduate program. For the M.A. in English, a minimum of 33 graduate credits is required. A thesis is required of all M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be met by successful performance in any one of the following options: (1) critical and scholarly competence in one area of the literature of a foreign language; (2) reading, writing, and speaking knowledge of one foreign language; (3) reading knowledge of two foreign languages; or (4) reading knowledge of one foreign language and demonstrated competence (normally by successful course work) in a technique such as computer science, statistics, etc., where relevant to the student's research interest.

Students with a 3.30 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.30 grade-point average may be made for students with special backgrounds, abilities, and interests. Graduate Record Examination scores are required.

ENGLISH (ENGL)

- 407. HISTORY OF THE ENGLISH LANGUAGE (3)
- 408. APPLIED ENGLISH LANGUAGE ANALYSIS (3)
- 410. RHETORICAL THEORY AND PRACTICE (3)
- 411. PROBLEMS OF STYLE (3)
- 412. THE WRITING OF FICTION (3-6)
- 413. VERSE WRITING (3-6)
- 414. BIOGRAPHICAL WRITING (3)
- 415. NONFICTION WRITING (3 per term, maximum of 6)
- 416. (Journ. 416) SCIENCE WRITING (3-6)
- 417. THE EDITORIAL PROCESS (3)
- 418. ADVANCED TECHNICAL WRITING AND EDITING (3-6)
- 430. MASTERS OF AMERICAN LITERATURE (3-6)
- 431. MOVEMENTS IN AMERICAN LITERATURE (3-6)
- 432. THE AMERICAN NOVEL TO 1900 (3)
- 433. THE AMERICAN NOVEL SINCE 1900 (3)
- 435. THE AMERICAN SHORT STORY (3)
- 437. AMERICAN POETRY (3)
- 438. AMERICAN DRAMA (3)
- 439. AMERICAN NONFICTION PROSE (3)
- 440. STUDIES IN BRITISH LITERATURE (3-6)
- 441. CHAUCER (3)
- 443. THE ENGLISH RENAISSANCE (3)

444. SHAKESPEARE: THE GENRES (3)
 445. SHAKESPEARE'S CONTEMPORARIES (3)
 446. MILTON(3)
 451. THE RESTORATION AND THE EIGHTEENTH CENTURY (3)
 455. THE NOVEL IN ENGLAND TO JANE AUSTEN (3)
 460. THE ROMANTICS (3)
 464. THE VICTORIANS (3)
 465. VICTORIAN NOVEL (3)
 470. LITERATURE OF THE BRITISH COMMONWEALTH (3)
 475. MODERN BRITISH FICTION (3)
 477. MODERN POETRY (3)
 478. BRITISH AND IRISH DRAMA SINCE 1890 (3)
 484. (L.A.484) COMPUTATIONAL AND QUANTITATIVE STYLISTICS (3)
 488. (C.Lit. 488) MODERN CONTINENTAL DRAMA (3)
 491. LITERATURE FOR TEACHERS IN SECONDARY SCHOOLS (3)
 492. HISTORY OF ENGLISH LITERARY CRITICISM (3)
 495. THE FOLKTALE IN AMERICAN LITERATURE (3)
 496. INDEPENDENT STUDIES (1-12)
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501. MATERIALS AND METHODS OF RESEARCH (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major.
 502. THEORY AND TEACHING OF COMPOSITION (3) Study of grammar, logic, rhetoric, and style in their applicability to teaching composition.
 506. THE ENGLISH LANGUAGE (3) A problem-centered approach to literary and oral forms of English, utilizing historical and analytic perspectives.
 512. THE WRITING OF FICTION (3-6) Supervised workshop in advanced techniques of writing fiction.
 513. THE WRITING OF POETRY (3-6) For the student with considerable experience in writing poetry; a workshop devoted to advanced poetic technique.
 515. THE WRITING OF NONFICTION (3-6) Supervised workshop in advanced nonfiction techniques.
 520. THE MIDDLE ENGLISH ROMANCE (3) A detailed study of the Middle English metrical romance in terms of its milieu and its genre in the West.
 521. OLD ENGLISH LANGUAGE (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry.
 522. BEOWULF (3) Reading and critical analysis. Prerequisite: Engl. 521.
 523. WORDSWORTH AND COLERIDGE (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period.
 524. BYRON AND SHELLEY (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period.
 525. BLAKE AND KEATS (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period.
 526. TENNYSON AND BROWNING (3)
 536. HENRY JAMES (3) The development of James as critic, novelist, and short story writer.
 540. STUDIES IN ELIZABETHAN PROSE AND POETRY (3-6)
 541. MEDIEVAL STUDIES (3-6) Special problems in medieval English literature.
 542. MIDDLE ENGLISH LITERATURE (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer.
 543. STUDIES IN EARLY SEVENTEENTH-CENTURY LITERATURE (3-6) Major poets and prose writers from 1600 to 1660.

544. RESTORATION LITERATURE (3) Selected studies of writers in England between 1650 and 1700.
545. CHAUCER (3-6) Critical study of the *Canterbury Tales* or *Troilus and Criseyde* and minor poems.
546. MILTON (3) The poetry and prose of John Milton.
548. ELIZABETHAN AND JACOBEAN DRAMA (3-6) English drama from 1558 to 1642, exclusive of Shakespeare.
549. SHAKESPEARE (3-6) Special problems of sources, chronology, text, characterization, and motivation in the drama.
552. SWIFT AND POPE (3)
553. THE AGE OF JOHNSON (3) The work of Johnson and his circle.
554. STUDIES IN EARLY AMERICAN LITERATURE (3)
556. EIGHTEENTH-CENTURY BRITISH FICTION (3)
557. EARLY EIGHTEENTH-CENTURY BRITISH LITERATURE (3) Prose and poetry in the reign of Queen Anne, with special attention to periodical publications.
560. AMERICAN ROMANTICISM (3) The romantic movement in American literature of the mid-nineteenth century.
561. STUDIES IN THE ROMANTIC MOVEMENT (3-6)
562. STUDIES IN THE LITERATURE OF VICTORIAN ENGLAND (3-6)
564. STUDIES IN NINETEENTH-CENTURY AMERICAN LITERATURE (3) The major figures treated will vary from year to year.
573. STUDIES IN TWENTIETH-CENTURY BRITISH LITERATURE (3-6) Major writers and literary movements.
574. STUDIES IN TWENTIETH-CENTURY AMERICAN LITERATURE (3-6) Major writers and literary movements.
575. JAMES JOYCE (3-6) Alternate terms: *Ulysses* and *Finnegans Wake*. Knowledge of *Dubliners* and *A Portrait of the Artist* is assumed.
576. HEMINGWAY AND FAULKNER (3) The major works.
578. SHAW (3) The plays, prose writings, and literary influence of G.B.S.
579. T. S. ELIOT (3) Major works in poetry, criticism, and drama; pertinent scholarship and criticism.
580. ANGLO-AMERICAN APPLICATIONS OF FOLKLORE IN LITERATURE (3) A detailed examination of the nature of the folktale and its implications for literature as an oral genre. Prerequisite: a basic knowledge of folklore, as taught in Engl. 196, is assumed.
581. CONTEMPORARY LITERARY CRITICISM (3)
582. HAWTHORNE AND MELVILLE (3) Detailed study of the major works of both authors and of the relationship between the two men.
583. EMERSON AND THOREAU (3) The significant prose and poetry of the chief American transcendentalists.
584. WHITMAN AND DICKINSON (3) The major texts, with special emphasis on background and language.
586. READINGS IN LITERATURE (1-12) Programs of readings designed to meet specific needs of individual students.
587. FRANKLIN AND EDWARDS (3) Studies in the lives, works, and milieu.
588. STUDIES IN AMERICAN FICTION (3-6)
589. STUDIES IN AMERICAN POETRY (3-6)

- 590. COLLOQUIUM (1-3)
- 592. STUDIES IN AMERICAN LITERARY MYTH (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture.
- 593. (C.Lit. 593) ANGLO-AMERICAN FOLK SONG (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present.
- 595. STUDIES IN BRITISH FICTION (3-6)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

ENTOMOLOGY (ENT)

CHARLES W. PITTS, *Head of the Department*
 106 Patterson Building
 814-865-1895

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Benton, Cameron, Hower, Kim, Mumma, Pitts, Rutschky, Smilowitz, Smyth, Snetsinger, and Yendol.

Graduate Faculty: Associate Members Bode, Byers, Collison, Hull, and Jubb.

A student majoring in entomology may specialize in economic entomology, forest entomology, apiculture, insect resistance in plants, arachnology, medical or veterinary entomology, biological control, insect pathology, insect transmission of plant pathogens, ecology, morphology, embryology, taxonomy, physiology, insect behavior, or chemistry of pesticides.

The enrichment requirement for the Ph.D. degree may be satisfied by taking at least 9 credits of study in a discipline other than entomology. There is no foreign language requirement for the Ph.D. degree.

For admission a student is required to have 24 credits in entomology and related biological sciences. Chemistry through organic, physics, mathematics through calculus, and statistics are required. A limited deficiency may be made up while pursuing graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENTOMOLOGY (ENT)

- 401. MEDICAL AND VETERINARY ENTOMOLOGY (3) *Kim*
- 412. FIELD ENTOMOLOGY (3) *Rutschky*
- 414. INSECT MORPHOLOGY AND PHYLOGENY (3) *Rutschky*
- 415. INSECT PHYSIOLOGY AND BIOCHEMISTRY (3) *Mumma and Smyth*
- 416. METHODS FOR INSECT PEST POPULATION MANAGEMENT (3) *Hower*
- 418. FOREST ENTOMOLOGY (3) *Cameron*
- 425. FRESHWATER ENTOMOLOGY (3) *Kim*
- 426. IMMATURE INSECTS (3) *Shetlar*
- 435. ARACHNOLOGY (3) *Snetsinger*
- 450. INSECT CONTROL IN GREENHOUSE (1) *Shetlar and Snetsinger*
- 451. INSECT CONTROL OF ORNAMENTALS AND TURF (2) *Shetlar and Heller*
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 515. INSECT MORPHOLOGY AND SYSTEMATICS (1-3) Current theories, controversies and advanced techniques in comparative morphology, histology, embryonic and postembryonic development, taxonomy and systematics of insects.
- 516. INSECT PHYSIOLOGY AND BIOCHEMISTRY (1-3) Selected topics in insect function and metabolism.
- 517. INSECT ECOLOGY AND BEHAVIOR (1-3) Selected aspects of the biotic and abiotic interactions of insects.
- 518. PEST MANAGEMENT (1-3) Current concepts and controversies in modern agricultural and urban pest management practice.
- 531. INSECT TOXICOLOGY (2) General principles of toxicology and survey of the actions of substances toxic to insects.
- 532. INSECT BEHAVIOR (2) Orientation reflexes, learning, communication, and social behavior; physiological bases; ecological and evolutionary implications.
- 535. BIOLOGICAL CONTROL (3) Practical and theoretical aspects of arthropod control by entomophagous insects and the place of biocontrol in integrated control programs.
- 536. INSECT PATHOLOGY (3) Diseases of arthropods and some aspects of microbial control of insects. Prerequisite: Micrb. 1.
- 542. (Biol. 542) SYSTEMATICS (3) Principles and methods of classification, phylogeny and speciation; taxonomic techniques; analysis of species, causal interpretation of animal diversity.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

ENVIRONMENTAL ENGINEERING (ENV E)

ROBERT M. BARNOFF, *Head of the Department of Civil Engineering*
 212 Sackett Building
 814-865-8391

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Aron, Heinsohn, Long, McDonnell, Miller, Nesbitt, Reed, Regan, Untrauer, and Unz.

Graduate Faculty: Associate Members Chadderton and Kibler.

This program prepares students for careers in (1) facility and system design; (2) systems management; (3) environmental monitoring; (4) process development; or (5) education and research in any of the environmental areas of water quality management (potable, industrial, and wastewater), water resources, management, and air pollution control.

The entering student normally should be a graduate from an accredited program in engineering.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Entering graduate students for whom English is not the first language are required to have a score of at least 575 on the TOEFL (Test of English as a Foreign Language) examination. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of one foreign language (French, German, Russian, or Spanish) and proficiency in English. A thesis is required for the M.S. degree. An engineering report is required for the M.Eng. degree.

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in environmental engineering (course descriptions are given under Civil Engineering): C.E. 451, 452, 462, 465, 471, 472, 474, 475, 476, 551, 553, 564, 571, 572, 573, 574, 575, 577, 579, and 580. Appropriate courses offered by other departments include: Ag. 400; Ag.Ec. 442, 505; Bioch. 401, 402, 425; Biol. 410; Chem. 405; Cmp.Sc. 402; Geosc. 452; I.E. 403, 405, 509, 510; M.E. 405, 470, 506, 521, 571; Meteo. 473, 502; Micrb. 400, 417; Nuc.E. 420; Pl.Sc. 419; P.Path. 424; Pub.A. 578; R.Pl. 400, 410, 510, 520.

ENVIRONMENTAL POLLUTION CONTROL (E P C)

JOHN B. NESBITT, *In Charge of Graduate Programs in Environmental Pollution Control*
226 Merrell R. Fenske Laboratory
814-865-1226

Degrees Conferred: M.S., M.E.P.C., M.Eng.

Graduate Faculty: Senior Members Aplan, Aron, Baker, Bartlett, Barton, Buskirk, Cunningham, de Maine, de Pena, Draper, Engel, Gordon, Heicklen, Heinsohn, Hunt, Kabel, Kamon, Knight, Kroger, Long, Lovell, Massaro, McDonnell, McKee, Michael, Nesbitt, Palmer, Panofsky, Parizek, Petersen, Reethof, Regan, Schenck, Simkovich, Sink, Stahl, Stephenson, Thomson, Unz, Walker, Witzig, and Zarkower.

Graduate Faculty: Associate Members Bienvenue, Chadderton, Davis, DeTar, Ferguson, Goodwin, Jarrett, Kibler, Mayers, Olsen, Patton, and Thuering.

This intercollege program deals with the various aspects of the control of air and water pollution and the disposal of solid wastes. Options in air, water, solid waste, and occupational health are available. Graduate instruction is under the direction of an interdisciplinary faculty committee and the departments participating in the program. The graduate faculty consists of members who have a teaching and/or research interest in the area of environmental pollution control.

Students are required to pass 9 credits of core courses: C.E. 472, Water Pollution Control; C.E. 476, Solid Waste Management; and M.E. 470, Fundamentals of Air Pollution. In addition, they must select at least 21 of their total credits from a recommended course list and schedule the environmental pollution control seminars (E.P.C. 590) for three terms. If the option to prepare a thesis is selected, the research topic must be in the area of environmental pollution control and at least 6 credits of research must be taken in the department with which the student is affiliated. Students who select the nonthesis option must submit a paper. The student's adviser, the department head, and the E.P.C. program chairman determine the requirements of the paper.

Admission will be granted upon recommendation of the head of the academic department with which the student plans to affiliate and the environmental pollution control program chairman. Normal admission requirements include mathematics through integral calculus, plus two courses each in both general physics and chemistry. There is no foreign language requirement. Students with a 2.75 junior-senior average and with appropriate backgrounds in mathematics and science will be considered for admission. The best-qualified applicants will be accepted. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Entering graduate students for whom English is not the first language are required to have a score of at least 560 on the TOEFL (Test of English as a Foreign Language) examination.

ENVIRONMENTAL POLLUTION CONTROL (E P C)

590. COLLOQUIUM (1-3)

EXTENSION EDUCATION (EXTED)

DARYL K. HEASLEY, *Acting Chairman of the Committee on Extension Education*
204 Weaver Building
814-865-0455

Degrees Conferred: M.Agr., M.Ed.

Program Committee: Heasley, Ritter, and Shellenberger
Cooperating Faculty: Baylor, Cole, Kuhn, Lindley, Sherritt, Snetsinger, and Wuest.

This program is designed primarily to meet the needs of professionals in various extension, vocational, and adult education positions. The purpose is to educate individuals to develop attitudes, understandings, and competencies which enable them to become more effective professionals. The advisory committee will assist the student in establishing goals, planning a program of study, selecting appropriate courses, and developing a professional paper within the requirements of the degree program.

For either degree a minimum of 30 credits is required, including a professional paper. These credits should be distributed as follows: 12 credits in extension techniques, communication, and education; 3-4 credits in statistics; at least 6 credits in a minor area of interest; up to 6 credits as electives; and 3 credits for the professional paper. For the M.Ed. degree a minimum of 6 credits in education courses is required. It is suggested that 12 of the 27 credits in course work be taken at the 500 level. A maximum of 10 credits can be earned as a nonresident student.

Admission requirements include a baccalaureate degree from an accredited institution, with the student having a strong background in agriculture, home economics, community development, or adult education, and a minimum of 12 credits in the social sciences. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Graduate Record Examinations scores (GRE scores) are required by the Graduate School.

EXTENSION EDUCATION (EXTED)

515. (R.Soc. 515) THE COOPERATIVE EXTENSION ORGANIZATION (3) The Cooperative Extension Service as a social system, with emphasis on techniques of organization and program development. Prerequisite: 9 credits in education, communication, and/or social sciences. *Thomson*

FOOD SCIENCE (FD SC)

DAVID R. LINEBACK, *Head of the Department*
111 Borland Laboratory
814-865-5444

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Beelman, Dimick, Keeney, Kroger, Kuhn, Lineback, MacNeil, Mason, Mast, McCarthy, Patton, Sink, Thompson, and Ziegler.

Graduate Faculty: Associate Members Forsythe, Glass, and Kilara.

Opportunities are available for study in the fields of biochemistry and metabolism, food chemistry (carbohydrates, lipids, proteins, enzymes), microbiology, quality control, flavor control and acceptance, product evaluation, and processing. Special emphasis can be devoted to dairy, meat, plant, and poultry products, and other specific food commodities.

The requirements for the M.S. and Ph.D. programs are detailed in the Department of Food Science's publication, *Graduate Programs in Food Science*. The communication and foreign language requirement for the Ph.D. degree may be satisfied by demonstration of an intermediate knowledge of one foreign language or through completion of three courses in English language communication.

Prerequisite to graduate work is the completion of an undergraduate degree in food science, biochemistry, microbiology, or other related areas. The undergraduate program must include calculus, organic chemistry, microbiology, and general physics. Students may be admitted with deficiencies but are required to make them up without degree credit. Students who present a 3.00 junior-senior average will be considered for admission to the program, subject to the limitations of the physical facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

In addition to the courses listed below, the following courses are available in food science: A.I. 431; Ag.E. 412, 413, 414, 423, 503; A.Ntr. 401; D.Sc. 427; Hort. 528; Pty.Sc. 504.

FOOD SCIENCE (FD SC)

- 400. FOOD CHEMISTRY (3)
- 403. QUALITY ASSURANCE AND SANITATION (3)
- 404. SENSORY EVALUATION OF FOODS (2)
- 405. THERMAL PROCESSING (2)
- 407. FOOD TOXINS (2)
- 408. APPLIED FOOD MICROBIOLOGY (2)
- 409. LABORATORY IN APPLIED FOOD MICROBIOLOGY (2)
- 410. CHEMICAL METHODS OF FOOD ANALYSIS (4)
- 415. MEAT SCIENCE AND TECHNOLOGY (3)
- 421. TECHNICAL CONTROL PROBLEMS (1-6)
- 490. UNDERGRADUATE SEMINAR (1)

- 505. CONCEPTS OF PRODUCT DEVELOPMENT (3) Interrelationships of processing principles and chemical and physical properties in the development of new and improved food products.
- 507. FOOD QUALITY, FOOD STANDARDS, AND CONSUMER PROTECTION (2) Problems of the food industry relating to contamination and quality of food products.
- 515. EXPERIMENTAL MEAT SCIENCE AND MUSCLE BIOLOGY (2-6) Experimental and theoretical aspects of meat science, meat product/process systems, and the quantitative biology of muscle systems used for food. Prerequisite: Fd.Sc. 400 or 415.
- 521. RADIOBIOLOGY (3) Radioactivity: its nature, interaction with matter, measurement, and quantification; the use of isotopes as tracers in biological systems.
- 522. RESEARCH PROCEDURES IN FOOD SCIENCE (3) Research problems and methods in food science with major emphasis on food chemistry.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

FOREST RESOURCES (FOR R)

ROBERT S. BOND, *Director of the School of Forest Resources*
 101 Ferguson Building
 814-865-7541

Degrees Conferred: Ph.D., M.S., M.Agr., M.F.R.

Graduate Faculty: Senior Members Blankenhorn, Bond, Bowersox, DeWalle, George, Gerhold, Hutnik, Labosky, Lindzey, Myers, Shipman, Sopper, Steiner, Storm, Turner, Twilight, and Ward.

Graduate Faculty: Associate Members Baldwin, Daugherty, Halverson, Heisler, Johnson, Kelly, Kersavage, Lynch, McCormick, Melton, Rader, Reyburn, Strauss, and Wakeley.

The Doctor of Philosophy and the Master of Science degree programs are oriented toward research, education, and scientific technology in the professions of forest products, forestry, and wildlife management. The foreign language requirement for the Ph.D. degree may be satisfied by demonstrating competence in one foreign language equivalent to passing three college-level courses.

The Master of Forest Resources is a professional degree which emphasizes application of knowledge through managerial practices involving forest resources, industries, or the natural environments of communities and recreational areas.

The Master of Agriculture is intended to enable students to develop skills as professionals in the communication of technical knowledge. Candidates will elect a minimum of 15 credits of graduate-level courses in communication skills from courses in departments such as Agricultural Education, Instructional Media, Journalism, Recreation and Parks, Speech Communications, English, and Theatre. Any deficiencies in a student's resource specialty, as judged by his or her advisory committee, must be remedied. An acceptable paper on a selected professional problem or a report of internship training worth 3 credits or more is also required.

A thesis is required for the M.S. and Ph.D. degrees, and an original paper is required for the M.F.R. degree. Most programs of study are strengthened by including appropriate courses offered by related departments.

Faculty expertise, laboratories, and outdoor research facilities are available to support specialization in a variety of fields. Possibilities for specialization are indicated in part by the courses listed under forest products, forestry, and wildlife, and by related courses in agricultural economics, agronomy, animal nutrition, biology, business administration, chemical engineering, computer science, ecology, economics, entomology, environmental pollution control, environmental resource management, genetics, horticulture, industrial engineering, landscape architecture, meteorology, physiology, plant pathology, polymer sciences, recreation and parks, regional planning, or statistics.

For admission, an applicant should have at least a 2.75 grade-point average, a 3.00 junior-senior average, and courses that are basic to the individual's field of specialization. Ordinarily these include 12 credits in communication, 12 credits in social sciences and humanities, 12 credits in quantification including calculus and statistics, 9 credits in physical sciences, 9 credits in biological sciences, and 18 credits in forest products, forestry, wildlife, or related courses. Graduate Record Examination scores, three reference reports (forms supplied on request), and a brief statement describing the applicant's academic goals, career interests, and special qualifications are required. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to admission requirements may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 239).

FOREST PRODUCTS (F P)

401. WOOD SCIENCE CONCEPTS (2)
402. WOOD SCIENCE PRACTICUM (1)
411. WOOD-ENVIRONMENTAL RELATIONSHIPS (3)
412. WOOD IN STRUCTURES (3)
413. THE CHEMISTRY OF WOOD (3)
414. PULP AND FIBER TECHNOLOGY (3)
420. PROCESSING AND MACHINING OF WOOD AND WOOD PRODUCTS (2)
421. GLUING AND FINISHING WOOD (2)
422. DRYING OF WOOD (2)
423. DETERIORATION AND PROTECTION OF WOOD PRODUCTS (2)
424. COMPOSITE WOOD PRODUCTS (2)
430. FOREST PRODUCTS INTERNSHIP (1-6)
432. FOREST PRODUCTS MANUFACTURING SYSTEMS (3)
435. FOREST PRODUCTS PRODUCTION MANAGEMENT (3)
439. PULP AND TIMBER HARVESTING (3)
490. FOREST PRODUCTS COLLOQUIUM (1)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

502. **WOOD FIBERS (3)** Identification and measurement of physical and chemical characteristics of wood fibers used in paper or dissolving pulps.
511. **PHYSICAL PROPERTIES OF WOOD AND FIBERS (2)** Theories of accessibility, sorption, dimensional stabilization, diffusion, and permeability of cellulosic fibers and solid wood. Prerequisite: F.P. 411.
513. **WOOD CHEMISTRY (3)** Treatment of the chemical components of wood, their distribution and reactions. Prerequisite: F.P. 413.
530. **FOREST PRODUCTS INDUSTRIAL OPERATIONS ANALYSIS (2)** Research methods with emphasis on programming, simulation, and waiting line problems. Prerequisite: F.P. 435.
531. **MECHANICAL BEHAVIOR OF WOOD (3)** Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.
532. **THEORY OF ADHESION (3)** Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

FORESTRY (FOR)

403. **DENDROLOGY (3)**
416. **FOREST RECREATION (3)**
421. **SILVICULTURE (3)**
430. **FORESTRY INTERNSHIP (1-6)**
440. **FOREST ECONOMICS AND FINANCE (3)**
450. **INTRODUCTION TO OPERATIONS RESEARCH (3)**
455. **INTRODUCTION TO REMOTE SENSING (3)**
466. **FOREST RESOURCE MANAGEMENT (3)**
470. **WATERSHED MANAGEMENT (3)**
480. **POLICY AND ADMINISTRATION (3)**
496. **INDEPENDENT STUDIES (1-12)**
497. **SPECIAL TOPICS (1-6)**
508. **FOREST ECOLOGY (3)** The forest ecosystem, variations in space and time, classification, ordination techniques, dynamic aspects such as energy flow and nutrient cycling.
512. **FOREST GENETICS (3)** Qualitative and quantitative genetic principles and research methods applied in tree breeding.
517. **FOREST MICROCLIMATOLOGY (3)** A quantitative treatment of climate near the ground, with special reference to the role of forests and terrain. Prerequisite: Phys. 202.
519. **FOREST HYDROLOGY (3)** Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisites: For. 308, C.E. 51.
521. **ADVANCED SILVICULTURE (3)** Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.
525. **FOREST LAND USE (3)** Concepts of supply and demand for forest lands and their allocation to alternative uses. Prerequisites: For. 466 or Ag.Ec. 421; or Geog. 405 and 3 credits in economics.
550. **MULTIVARIATE ANALYSIS IN FORESTRY RESEARCH (3)** Analysis and interpretation of research data involving several response variables. Includes computational considerations for large data sets. Prerequisite: Stat. 402.

555. **MULTISPECTRAL REMOTE SENSING (3)** Computer analysis of data from nonimaging remote sensors as applied to mapping of natural resources and land use. Prerequisites: Cmp.Sc. 101, For. 455.
560. **TIMBER MANAGEMENT (3)** Technical methods in the organization and control of the forest property for timber production.
575. **APPLICATIONS OF FOREST ECONOMICS AND FINANCE (3)** Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 440.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

NOTE: See also *Wildlife Management*.

FRENCH (FR)

RICHARD L. FRAUTSCHI, *Head of the Department*
316 Burrowes Building
814-865-1492

Degrees Conferred: Ph.D., D.Ed., M.A.

Graduate Faculty: Senior Members Brault, Chapman, Frautschi, Hale, Knight, Norton, and Ward.

Graduate Faculty: Associate Members Ariew, Boisset, Bragger, Danahy, and Makward.

This program offers training in language, literature, linguistics, and civilization. A candidate for the M.A. degree may select a program of study emphasizing language with cultural emphasis or literature. A reading knowledge of a second foreign language and written and oral comprehensive examinations are required. The candidate may submit either a thesis or a term paper. If the latter is chosen, 6 additional credits in 500-level courses must be scheduled. The M.A. degree (or equivalent) is normally a prerequisite to doctoral candidacy.

The D.Ed. degree is structured for students preparing careers emphasizing teaching, curriculum design, and administration in secondary and post-secondary education. Of the 90 required graduate credits, a minimum of 60 (including M.A. credits) must be acquired in French courses and another 15 in the College of Education. A reading knowledge of a second foreign language is also required. A thesis focusing on a pedagogical topic is selected and may be supervised by faculty in both French and education.

The Ph.D. degree prepares candidates for careers in teaching and research at the college level. A minimum of 66 credits (including M.A. credits) is required in graduate course work, 36 of which must be distributed in metropolitan literature. Candidates may specialize in French literature, linguistics, francophone literature, or, with special permission, interdisciplinary study in the humanities, social sciences, or fine arts. The communication and foreign language requirement for the Ph.D. degree may be satisfied by at least a reading knowledge of two foreign languages other than French.

The minimum requirement for admission to an advanced degree program will normally be 36 credits of post-intermediate work in language and literature. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. A brief tape recording of an original composition in French must be presented before admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

FRENCH (FR)

*1G. ELEMENTARY FRENCH FOR GRADUATE STUDENTS (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. ELEMENTARY FRENCH FOR GRADUATE STUDENTS (3) Continuation of Fr. 1G with reading practice.

500. INTRODUCTION TO OLD FRENCH (3) Analysis of the phonology, morphology, and syntax of Old French based on early literary monuments. *Brault*

503. FRENCH PHONOLOGY (3) Articulatory and acoustic correlates of distinctive features; synchronic dialectology; phonology in generative grammar. *Boisset*

504. FRENCH MORPHOLOGY AND SYNTAX (3) Principles of segmentation and decomposition; tagmemics and transformation theory; morphophonemics. *Boisset*

505. SEMANTIC THEORY OF THE FRENCH LANGUAGE (3) The goals of semantic description; systematic interrelation of semantic generalizations; empirical and methodological constraints. *Belasco*

510. STYLISTIQUE AVANCÉE (3) Study of rhetorical figures and expository style in prose and poetry through *dissertation* and *explication*.

511. READINGS IN OLD FRENCH (3 per term, maximum of 6) A survey of French literature to 1300, focusing in alternate terms on either the 12th or the 13th century. *Brault*

512. LATE MEDIEVAL FRENCH LITERATURE (3) The non-dramatic literary genres of the late Middle Ages, with reference to their cultural context and social function. *Knight*

516. THE SONG OF ROLAND (3) Seminar in the Old French *Chanson de Roland*, with emphasis on the problems of textual criticism and literary analysis. *Brault*

518. MEDIEVAL FRENCH DRAMA (3) The development of French drama from its liturgical origins to the flourishing comic theatre of the late Middle Ages. *Knight*

526. AGE OF RABELAIS (3) Notions of literary creativity in the context of early sixteenth-century French Humanism: readings from Rabelais, Marguerite de Navarre, Scève. *Norton*

529. SEMINAR IN RENAISSANCE LITERATURE (3 per term, maximum of 6) Intensive study of various French Renaissance writers in relation to selected artistic issues of the period. *Norton*

528. AGE OF MONTAIGNE (3) Literary culture of Renaissance France in the context of social and political crisis; readings from Montaigne, DuBellay, Ronsard, and Sponde. *Norton*

533. SEVENTEENTH-CENTURY PROSE AND POETRY (3) The development of classicism; its apogee and decline as seen in the works of major prose writers and poets. *Chapman*

534. MOLIÈRE (3) The literary achievement of Molière, the comic playwright, director, actor, and founder of the Comédie Française. *Chapman*

535. SEVENTEENTH-CENTURY FRENCH TRAGEDY (3) The development and triumph of tragedy as a literary genre with special emphasis on the achievement of Corneille and Racine. *Chapman*

540. VOLTAIRE AND HIS CONTEMPORARIES (3) The artistic and philosophical evolution of Voltaire as seen in the tragedy, the philosophical tale, and poetry. *Frautschi*

541. ROUSSEAU AND HIS CONTEMPORARIES (3) Rousseau's rationalistic critique of civilization; his sentimental rehabilitation of the individual, family, state; Rousseau, precursor of romanticism. *Frautschi*

543. SEMINAR: STUDIES IN THE ENLIGHTENMENT (3 per term, maximum of 6) Discourse and thematic analysis of selected works of French Enlightenment genres: essay, drama, fiction, poetry. *Frautschi*

*No graduate credit is given for this course.

561. FRENCH ROMANTICISM (3) The romantic movement in French literature with emphasis upon its major exponents in prose and poetry. *Danahy*
563. FRENCH REALISM (3) The realistic movement in French literature with emphasis upon its major exponents in prose and poetry. *Danahy*
565. SEMINAR: NINETEENTH-CENTURY STUDIES (1-6) Various nineteenth-century French writers considered in relation to selected esthetic and cultural problems raised during the period. *Danahy and Ward*
569. MASTERS OF TWENTIETH-CENTURY FRENCH LITERATURE (3-6) Major literary figures of contemporary French literature. *Makward*
570. MODERN FRENCH POETRY (3 per term, maximum of 6) Historical overview through readings from major poets since Baudelaire; introduction to basic concepts in criticism of poetry.
571. FRENCH LITERARY CRITICISM FROM SAINTE-BEUVE TO PRESENT (3) Evolution of French literary criticism from Sainte-Beuve, the "father" of modern literary criticism, to contemporary critics.
572. SEMINAR: TWENTIETH-CENTURY FRENCH LITERATURE (3 per term, maximum of 6) Specialized consideration of contemporary writers; for advanced students.
581. THEORY AND TECHNIQUES OF TEACHING FRENCH (1-6)
595. ANALYSIS OF FRENCH CIVILIZATION (3-6) French cultural aspects, other than language and literature, conducted in French with the collaboration of specialists outside the French department.
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

FUEL SCIENCE (F SC)

PHILIP L. WALKER, JR., *In Charge of Graduate Programs in Fuel Science*
320 Steidle Building
814-865-6511

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Austin, Given, Palmer, Vastola, and Walker.

Graduate Faculty: Associate Members Becker, Jenkins, and Reuther.

Graduate work in fuel science provides advanced professional knowledge and research opportunities in the characteristics and utilization of fuels, including their conversion to energy, to other fuels, or to other materials.

Well-instrumented research facilities are available for investigation of the chemical and physical characteristics of coals, fundamentals of coal gasification and liquefaction, flame dynamics in practical combustion systems, industrial fuel efficiency, chemistry and physics of basic combustion phenomena, chemical kinetics of fast gaseous reactions, formation and removal of polluting species in combustion processes, physics and chemistry of carbonaceous solids, organic geochemistry of plant-derived sediments, modeling of energy systems, electrochemical energy conversion, and solar power generation. Students can plan a wide variety of programs of study to suit individual needs; coherent interdisciplinary programs are encouraged. The nonthesis option is available for the M.S. degree.

Competency in a foreign language is not required for the Ph.D. degree. Candidates are expected to demonstrate high proficiency in both written and spoken English.

Applications will be accepted from persons having degrees in the basic or applied physical sciences or in engineering. Students with a 2.75 junior-senior average normally will be considered for admission. Exceptions may be made for students with special abilities, interests, or backgrounds, such as extensive industrial experience in fuels or combustion.

FUEL SCIENCE (F SC)

- 421. FLAMES (3) *Palmer*
- 422. COMBUSTION ENGINEERING (3) *Reuther*
- 424. ENERGY AND FUELS IN TECHNOLOGICAL PERSPECTIVE (3) *Vastola*
- 430. AIR POLLUTANTS FROM COMBUSTION SOURCES (3) *Reuther*
- 431. THE CHEMISTRY OF FUELS (3) *Given*
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

506. CARBON REACTIONS (3) Current approaches to heterogeneous reactions in combustion and gasification of carbonaceous solids, including those derived from coal and petroleum sources. Prerequisite: Chem. 452. *Walker*

512. HIGH-TEMPERATURE KINETICS AND FLAME PROPAGATION (3) Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high-temperature gases. Prerequisite: F.Sc. 421. *Palmer*

520. THERMODYNAMICS AND KINETICS OF FUEL EFFICIENCY (3) Thermodynamic and kinetic constraints on efficiencies of thermal systems; efficiency ratios; furnace analysis; radiation in furnaces, applications and examples. Prerequisite: study of thermodynamics at the upperclass or graduate level. *Reuther*

522. FLAME DYNAMICS IN COMBUSTORS (3) Mixing and reaction in combustion chambers; combustor analysis; residence time distributions; perfectly and well-stirred combustors; models and experiments. *Reuther*

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

NOTE: Courses in the use of X-ray diffraction, electron microscopy, spectroscopy, and electronic instrumentation in fuel science studies are listed under Materials Science.

GENETICS (GENET)

HENRY D. GERHOLD, *Chairman of the Graduate Program in Genetics*
306 Forest Resources Laboratory
814-865-3281

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Ayers, Berlin, Bullock, Buss, Cleveland, Craig, Davidson, Deering, Docherty, Fritz, Garwood, Gerhold, Goodwin, Grun, Hargrove, C. W. Hill, R. R. Hill, Hunt, Jacob, M. Johnson, Jones, Keith, Lang, MacCluer, MacKenzie, Marshall, R. Nelson, Person, Rapp, Risius, Schengrund, Shannon, Shenk, Shiman, Snipes, Starling, J. Taylor, W. Taylor, Tevethia, Therrien, Todd, Vesell, Weisz, Wilson, Wright, Zagon, and Zimmerman.

Graduate Faculty: Associate Members Dyke, Eckhardt, Ferguson, Ladda, Liu, McCarthy, Petters, Pfeifer, Porter, Rose, Schlegel, S. Smith, Steiner, Stevens, W. J. White, and Yasbin.

The intercollege program in genetics includes faculty from the colleges of Agriculture, the Liberal Arts, Medicine, and Science who serve as major advisers and committee members. Applicants are encouraged to contact any faculty member who may be a prospective major adviser. Assistantship or fellowship applications should be submitted by January. Courses may be taken at either University Park or the Hershey Medical Center.

Opportunities for graduate study and research are available in biochemical, developmental, human, microbiological, viral, molecular, and population genetics; cytogenetics; pharmacogenetics; and

breeding of plants or animals. Organisms available for research include fungi, bacteria, viruses, fish, rodents, birds, domestic animals, humans, forest trees, and grain, forage, and horticultural plants. The committee appointed for each student, with the approval of the program chairman, has the responsibility for determining course work, specific requirements in communication skills exceeding the minimum, and research acceptable for satisfying degree requirements. The requirement in communication and foreign language skills for the Ph.D. degree may be satisfied by fulfilling the requirement of the thesis adviser's department or program.

Students with a grade-point average of 3.00 or better and with appropriate course backgrounds in biology, science, and communications courses will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Students with limited deficiencies may be admitted, but they must make up such deficiencies concurrently with their graduate studies.

The following genetics courses are available: Agro. 411, 509, 510, 511; An.Sc. 422, 455; Anthy. 400, 500; Bioch. 514; Biol. 422, 426, 427, 428, 429, 465, 533; B.Chem. 503; Bphys. 430, 589; C.Med. 503; For. 512; Hort. 407, 444, 514; Micrb. 516; Micro. 553, 556; Ped. 525, 526; Pharm. 515, 540; P.Path. 543. Twelve credits in these courses, including at least 3 credits in acceptable statistics courses, and 3 credits per year in genetics seminar (Genet. 590 or Pharm. 515) are required for the M.S. degree in genetics or a minor in genetics for a Ph.D.; 15 credits in these courses and 3 credits per year in genetics seminar are required for a Ph.D. major in genetics. Transfer credits for certain courses in genetics may be accepted as substitutes for the above-listed courses.

GENETICS (GENET)

590. COLLOQUIUM (1-3)

GEOGRAPHY (GEOG)

RONALD ABLER, *Head of the Department*
302 Walker Building
814-865-3433

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Abler, Downs, Erickson, Gould, Knight, Lewis, Miller, Rodgers, Simkins, Wernstedt, Williams, Yapa, and Zelinsky.

Graduate Faculty: Associate Member Goodwin.

The student may concentrate in subjects that call upon the special skills and interests of the staff. Current specialties in human geography include the American landscape; behavioral geography, the cultural and human geography of Africa, Anglo-America, Southeast Asia, and the U.S.S.R.; political geography; population problems; and urban geography. Economic specialties include applied geography, communications systems, the developing world, environmental pollution control, human use of the environment, industrial location, planning, and regional economic development. Methodological specialties include cartography, computer mapping, geographical theory, methods of geographical analysis, and statistical techniques in geography. All students must have or acquire competence in cartography and statistical analysis.

For the M.S. degree, the student has the option of completing a thesis or two papers. The master's program is broadly based, designed to provide a beginning graduate student with basic training in systematic fields, as well as in geographic theory and research techniques. This basic training underlies more specialized study at the doctoral level, where a candidate selects two fields of concentration. A student may elect to specialize in the geography of a region only if faculty members have research experience in that region. The communication and foreign language requirement for the Ph.D. degree shall be satisfied in a manner approved by the candidate's doctoral committee.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are

available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 239). The M.S. in environmental pollution control with a geography specialty is also available.

Qualified students also may select population issues as an optional area of specialization. In addition to departmental admission requirements, the Population Issues Research Center evaluates the student's interest and aptitude for the training program, which consists of a minimum of 21 credits of interdisciplinary course work in population.

GEOGRAPHY (GEOG)

401. HISTORICAL GEOGRAPHY OF NORTH AMERICA (3) *Lewis or Zelinsky*
402. CULTURAL AND ANTHROPOGEOGRAPHY (3) *Zelinsky*
405. GEOGRAPHY OF POPULATION (3) *Simkins or Zelinsky*
406. HUMAN USE OF ENVIRONMENT (3) *Knight*
410. CARTOGRAPHY — MAP DESIGN AND CONSTRUCTION (3) *Abler*
411. ADVANCED CARTOGRAPHY (3) *Abler*
412. THE GEOGRAPHY OF THE FUTURE (3) *Abler*
413. BEHAVIORAL APPROACHES TO GEOGRAPHY (3) *Downs*
416. LOW-ENERGY LIVING (3) *Goodwin*
420. URBAN GEOGRAPHY (3) *Erickson*
427. GEOGRAPHY OF THE SOVIET UNION (3) *Rodgers*
433. REGIONAL CLIMATOLOGY (3) *Wernstedt*
434. REGIONAL PHYSIOGRAPHY (3) *Lewis*
440. GEOGRAPHY OF MIDDLE AMERICA (3) *Simkins*
441. GEOGRAPHY OF SOUTH AMERICA (3) *Simkins*
442. REGIONAL SYSTEMS IN EUROPE (3) *Miller*
443. GEOGRAPHY OF THE ORIENT (3) *Wernstedt*
444. GEOGRAPHY OF AFRICA (3) *Knight*
445. GEOGRAPHY OF SOUTHERN ASIA (3) *Wernstedt*
450. DEVELOPMENT OF GEOGRAPHIC THOUGHT (3) *Abler*
451. MAP INTERPRETATION (3) *Lewis*
452. INTERPRETATION OF AERIAL PHOTOGRAPHS (3) *Goodwin*
454. SPATIAL ANALYSIS I (3) *Gould or Williams or Yapa*
455. SPATIAL ANALYSIS II (3) *Gould or Williams or Yapa*
457. GEOGRAPHIC DATA SYSTEMS (4) *Williams*
460. POLITICAL GEOGRAPHY (3) *Williams*
470. INDUSTRIAL LOCATION AND DEVELOPMENT (3) *Rodgers*
475. GEOGRAPHY OF COMMUNICATIONS SYSTEMS (3) *Abler*
495. DIRECTED READINGS (1-9)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

500. INTRODUCTION TO GEOGRAPHIC RESEARCH (3)
502. REGIONAL THEORY (3) Taxonomic methods of uniform-functional regionalization; canonical linkages; intraregional relationships; Wilson models of macrocanonical ensembles.
504. PHYSICAL GEOGRAPHY SEMINAR (3-12) The examination of current problems and theories in physical geography through critical discussion of the literature and student research.
505. ECONOMIC GEOGRAPHY SEMINAR (3-12) The examination of current problems and theories in economic geography through critical discussion of the literature and original student research.
508. CULTURAL GEOGRAPHY SEMINAR (3-6) The exploration of current problems and theory in cultural geography through critical discussion of the literature and original student research.
509. POPULATION GEOGRAPHY SEMINAR (3) Selected problems in population geography with emphasis on analysis and presentation of data. Prerequisite: Geog. 405.

510. ANALYTIC CARTOGRAPHY (3) Computer graphics, geographical matrix operations, response functions, sampling resolution, quantization, map generalization, pattern recognition, generalized spatial partitionings, and map projections. Prerequisites: Geog. 454, 455.
517. GEOGRAPHIC MODELING (1) Spatial modeling, mapping, and transformations of elementary geographic problems.
520. METROPOLITAN ANALYSIS (3) Land use models, urban factorial ecology; intraurban movements; urban renewal, ghetto structure, residential change; commercial structure, blight. Prerequisite: Geog. 420 or 454.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

GEOSCIENCES

C. WAYNE BURNHAM, *Head of the Department*
503 Deike Building
814-865-6711

There are three graduate degree programs to which a student can be admitted: geochemistry and mineralogy, geology, and geophysics. Transfer from one of these majors to another is possible, provided the basic admission requirements of the program into which the student is transferring are met.

For admission applicants are required to submit the results of the Graduate Record Examination and are generally expected to have a bachelor's degree in some branch of the natural or physical sciences, engineering, or mathematics. An applicant also is expected to have completed standard introductory courses in geosciences, chemistry, physics, and mathematics through integral calculus, plus 15 credits of intermediate-level work in one or a combination of these subjects. Greater than minimal preparation within these limits may be required in chemistry and mineralogy for the geochemistry and mineralogy major; in geology and biology for the geology major; and in mathematics and physics for the geophysics major. Applicants who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies. Students with special backgrounds, abilities, and interests whose undergraduate grade-point average in courses pertinent to geosciences is below a 3.00 will be considered for admission only when there are strong indications that a 3.00 average can be maintained at the graduate level. The student has the option of a thesis or a paper for the M.S. degree.

GEOSCIENCES (GEOSC)

401. GEOLOGIC PERSPECTIVES OF INDUSTRIAL ACTIVITIES (2)
402. (Meteo. 446) NATURAL DISASTERS SEMINAR (2)
403. GEOLOGICAL ASPECTS OF ENVIRONMENTAL PROBLEMS (3) *Dachille*
404. GEOLOGY OF THE SOLAR SYSTEM (3) *Dachille*
408. (Mat.Sc. 408) X-RAY DIFFRACTION (3) *Dachille*
409. CRYSTALLOGRAHY AND OPTICAL MINERALOGY (3) *Eggler and Thornton*
411. (Mat.Sc. 411) INSTRUMENTAL TECHNIQUES APPLIED TO MATERIALS AND MINERAL SCIENCES PROBLEMS (1-7)
- Unit A. X-RAY DIFFRACTION*
- Unit B. TRANSMISSION ELECTRON MICROSCOPY*
- Unit C. SPECTROSCOPY*
- Unit D. ELECTRON MICROPROBE ANALYSIS*
- Unit E. SCANNING ELECTRON MICROSCOPY*
- Unit F. ABSORPTION SPECTROSCOPY*
- Unit G. ION BEAM TECHNIQUES*
415. GEOCHEMISTRY (3) *Deines*

- 416. STABLE AND RADIOACTIVE ISOTOPES IN GEOSCIENCES: INTRODUCTION (3) *Ohmoto and Deines*
- 419. INTRODUCTION TO ORGANIC GEOCHEMISTRY (3) *Given*
- 420. (Biol. 420) PALEOBOTANY (3) *Spackman*
- 421. INTRODUCTION TO COAL PETROLOGY (3) *Davis*
- 422. COAL MEASURE GEOLOGY (3) *Davis*
- 423. (Biol. 423) INTRODUCTORY PALYNOLOGY (3) *Traverse*
- 425. FOSSILS (3) *Cuffey*
- 426. PALEOECOLOGY (3) *Cuffey*
- 427. (Biol. 427) EVOLUTION (3) *Cuffey and Traverse*
- 430. PETROLOGY (5)
- 431. PETROGRAPHY (3)
- 434. VOLCANOLOGY (3) *Thornton*
- 436. PETROLOGY AND GEOCHEMISTRY OF SEDIMENTS (3) *Williams*
- 438. BIOGENIC SEDIMENTATION (3) *Guber*
- *439. Stratigraphy (3) *Cuffey and Williams*
- 440. MARINE GEOLOGY (3) *Schmalz*
- 442. EVOLUTION OF COASTLINES (3) *Slingerland*
- 445. COASTAL GEOLOGY (4) *Guber, Schmalz, Slingerland, and Williams.*
- 451. ECONOMIC GEOLOGY (3) *Gold and Rose*
- 452. INTRODUCTION TO HYDROGEOLOGY (3) *Parizek*
- 454. GEOLOGY OF OIL AND GAS (3) *Scholten*
- 457. GEOCHEMICAL EXPLORATION (3) *Rose*
- 461. GEOLOGY OF NORTH AMERICA (3) *Wright*
- *462. PRINCIPLES OF GEOMORPHOLOGY (3-6) *Gardner*
- 465. STRUCTURAL GEOLOGY (3) *Gold*
- 466. MECHANICS OF GEOLOGICAL MATERIALS (3) *Voight*
- *470. INTRODUCTION TO FIELD GEOLOGY (3) *Gold and Wright*
- *471. FIELD STUDIES IN NORTH AMERICA (3)
- 472. FIELD GEOLOGY (7-8)
- 473. TOPOGRAPHIC MAPS AND AERIAL PHOTOGRAPHS (1)
- 480. PHYSICS OF THE EARTH (3) *Graham*
- 482. GEOPHYSICAL WELL LOGGING (3) *Lavin*
- 484. GEOPHYSICAL SURVEYING (3)
- 487. ANALYSIS OF TIME SERIES (3) *Lavin*
- 488. POTENTIAL THEORY APPLIED TO EARTH PROBLEMS (3) *Alexander*
- 490. GEOLOGICAL SCIENCES SEMINAR (1-6 per term)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

GEOLOGICAL SCIENCES (G SC)

- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

*This course includes from one to several field trips for which an additional charge will be made.

GEOCHEMISTRY AND MINERALOGY (G M)

DERRILL M. KERRICK, *In Charge of Graduate Programs in Geochemistry and Mineralogy*
204 Deike Building
814-863-0633

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barnes, Burnham, Dachille, Deines, Kerrick, Muan, Ohmoto, Rose, Roy, Smith, Thornton, and White.

Graduate Faculty: Associate Members Blencoe, Cathles, Egglar, Lasaga, and Suhr.

Areas of specialization include phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical exploration, cosmochemistry, high-temperature and high-pressure geochemistry, ore-forming processes, igneous, sedimentary, and metamorphic petrology, experimental petrology and mineralogy, crystallography, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 239).

GEOCHEMISTRY AND MINERALOGY (G M)

502. (Geol. 502) CARBONATES IN THE MARINE ENVIRONMENT (3) Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach.

503. (Mat.Sc. 503) KINETICS OF MATERIALS PROCESSES (3) Introduction to application of transition state theory and mass transfer to the kinetics of materials and mineral processes. Prerequisites: Math. 100, Chem. 451; G.M. 521 or Mat.Sc. 501. *Lasaga*

510. METAMORPHIC PETROLOGY (2-4 per term, maximum of 6) Analysis of theoretical, experimental, and field aspects of metamorphic reactions. Prerequisites: G.M. 520, 521, and Geosc. 432. *Kerrick*

512. (Mat.Sc. 512) PRINCIPLES OF CRYSTAL CHEMISTRY (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions. *Roy*

*513. SCIENTIFIC METHOD IN GEOSCIENCE (3) Problem formulation, sampling designs, selection of variates, and comparison of techniques for analysis of aggregates.

*514. STATISTICAL AND ELECTRONIC DATA-PROCESSING PROCEDURES FOR GEOSCIENCE (3) Statistical analysis of experimental data using univariate and bivariate procedures.

*515. ORE MICROSCOPY (3) Optical and hardness measurements and phase equilibria as used in identification and interpretation of textures of ore minerals. *Barnes*

518. STABLE ISOTOPE GEOCHEMISTRY (3) Theory of isotope fractionation mechanisms; its application to a wide range of problems in the earth and planetary sciences. *Deines*

519. PHASE EQUILIBRIA IN MINERAL SYSTEMS AT HIGH TEMPERATURES (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams. *Muan*

520. P-T-X PHASE EQUILIBRIA (3) Phase equilibrium in mineral systems with pressure as a variable. *Egglar*

521. MINERAL EQUILIBRIA (3) A thermodynamic treatment of minerals and their reactions under geochemically important conditions of temperature and pressure. Prerequisite: Chem. 451. *Muan and Lasaga*

*Offered alternate years.

522. GEOCHEMISTRY OF AQUEOUS SYSTEMS (2-3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, PO₂-pH relations applied to ground water, sea water, hydrothermal fluids. Prerequisites: Chem. 451-452; Geosc. 432, 436. *Barnes and Schmalz*
- *523. WATER-RESOURCE GEOCHEMISTRY (2-4) Topics and problems concerning the chemical quality of surface waters and ground waters related to hydrogeologic and cultural controls.
- *524. (Mat.Sc. 524) VIBRATIONAL SPECTRA OF MATERIALS AND MINERALS (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization and glass research. Prerequisites: Phys. 412, 471. *White*
- *525. ELECTRON PROPERTIES OF MINERALS (2) Application of spectroscopy to mineralogy, crystal field, EPR, NMR, Mossbauer spectra. Application to order-disorder, element distribution, mineral stability. Prerequisites: Phys. 412, 471. *White*
526. PROBLEM SOLVING IN GEOSCIENCE (3) Multivariate statistical analysis, decision making, operations research, and systems analysis in geoscience.
- *527. MINERALOGY I—SILICATES (3) Detailed study of the crystal structures and crystal chemistry of the silicate minerals. *Smith*
- *528. MINERALOGY II—NONSILICATES (3) Detailed study of the crystal structures and crystal chemistry of the nonsilicate minerals. *Smith*
- *531. (Mat.Sc. 531) TRANSMISSION ELECTRON MICROSCOPY (2) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences. Prerequisite: Min. 411B (Mat.Sc. 411B). *Thrower*
- *532. (Mat.Sc. 532) STRUCTURE ANALYSIS (2) Crystal structure determination methods; space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Geosc. 408 (Mat.Sc. 408). *Smith*
- *533. (Mat.Sc. 533) SINGLE CRYSTAL METHODS (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Geosc. 408 (Mat.Sc. 408). *Ryba*
- *534. (Mat.Sc. 534) DIFFRACTION BY CRYSTALS (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescence, polarization. Prerequisite: Geosc. 408 (Mat.Sc. 408). *McKinstry*
- *535. (Mat.Sc. 535) GEOMETRICAL CRYSTALLOGRAPHY (3) Derivation of lattices, types, point groups, and space groups, with applications. *Smith*
- *538. (Mat.Sc. 538) ELECTRON BEAM ANALYSIS OF SOLIDS VIA X-RAY AND ELECTRON EMISSION (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids.
542. ELEMENT DISTRIBUTION IN THE EARTH (3) Principles and data from studies of phase equilibria, petrology and crystal structure as related to distribution of elements in minerals, rocks, and the earth.
550. IGNEOUS PETROLOGY (2-3) Magmatic processes and their expression in the mineralogy, major and trace element chemistry, and isotopic composition of igneous rocks. Prerequisite: Geosc. 432. *Thornton*
551. PETROGENESIS (2-3) Application of theory and experimental results to the origin of igneous rocks. Prerequisites: G.M. 520, 521. *Burnham*
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

*Offered alternate years.

GEOLOGY (GEOL)

DAVID P. GOLD, *In Charge of Graduate Programs in Geology*
303 Deike Building
814-865-3934

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Cuffey, Davis, Gold, Guber, Parizek, Schmalz, Scholten, Spackman, Traverse, Voight, Williams, and Wright.

Graduate Faculty: Associate Members Gardner and Slingerland.

Programs are offered in stratigraphy, paleontology, sedimentation, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, engineering geology, marine geology and chemical oceanography, coal geology, coal petrology, and geology of metallic and nonmetallic deposits. The foreign language requirement for the Ph.D. degree may be satisfied by elementary competence in two languages other than English or by comprehensive competence in one.

GEOLOGY (GEOL)

502. (G.M. 502) CARBONATES IN THE MARINE ENVIRONMENT (3) Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach.

503. PALEONTOLOGY (3-6 per term, maximum of 9) Morphology of animal groups significant for their fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology. *Cuffey*

504. HISTORY AND FOUNDATIONS OF GEOLOGY (2-4) Theoretical aspects of geology: spatio-temporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought. *Williams*

505. QUANTITATIVE PHYSICAL SEDIMENTOLOGY (3) Principles of fluid mechanics and mathematical modelling; their use in describing sediment transport, sedimentary structure, and sedimentary environments. Prerequisite: Geosc. 330.

506. SEDIMENTS OF THE WORLD (2-3 per term, maximum of 6) Evolution of sediments from Archean to recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity. Prerequisites: Min. 512, 514. *Scholten and Williams*

508. CLASTIC DEPOSITIONAL ENVIRONMENTS (3) Readings, group discussions, and field work on processes and sedimentary responses of common rock-forming environments. Prerequisite: Geosc. 439.

509. (Mn.Ec. 509) GEOLOGY AND ECONOMICS OF THE CONSTRUCTION MATERIALS (3) Occurrence, origin, and marketing of the mineral materials used by the construction industry. Economic and geologic evaluation of actual deposits. *Schenck and Wright*

510. (Mn.Ec. 510) GEOLOGY AND ECONOMICS OF THE INDUSTRIAL MINERALS (3) Occurrence, origin, and marketing of the industrial minerals and evaluation of deposits. Chemical and ceramic raw materials emphasized. *Schenck and Wright*

511. ORE DEPOSITS: PRINCIPLES (3-6) Geological and geochemical processes controlling ore deposition; genetic classification of ore deposits. Prerequisite: Geosc. 451. *Staff*

512. ORE DEPOSITS: TYPES (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511. *Staff*

524. COAL PETROLOGY (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Davis*

526. (Biol. 526) **PROBLEMS IN PALYNOLOGY (1-6)** Systematics: paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history. *Traverse*
545. **GLACIAL GEOLOGY (3)** Glaciers: their characteristics, causes, deposits, landforms, effects in periglacial regions. *Parizek*
546. **PRINCIPLES OF PHOTOGEOLOGY (3)** Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: Geosc. 462, 465. *Gold*
551. **DYNAMIC STRUCTURAL GEOLOGY AND GEOTECTONICS (3-6)** Phenomena of fracturing, faulting, folding; stress and (finite) strain analysis, physical and analytical models; deformational environments; tectogenesis and orogenesis. *Scholten, Voight, and Wright*
555. **ADVANCED STRUCTURE AND PETROFABRICS (1-3)** Macroscopic and mesoscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks. *Gold*
562. **FLUVIAL GEOMORPHOLOGY (3)** Process-oriented analysis of the variables of the fluvial system, emphasizing man's interaction.
571. **FIELD PROBLEMS IN APPALACHIAN GEOLOGY (2)** Geologic history of the central Appalachians as deduced from field studies. *Slingerland*
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

GEOPHYSICS (GPHYS)

SHELTON S. ALEXANDER, *In Charge of Graduate Programs in Geophysics*
403 Deike Building
814-865-2622

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Alexander, Graham, Greenfield, Howell, and Lavin.

Graduate Faculty: Associate Members Langston and Martin

Students may specialize in seismology, physical properties of rocks, geophysical surveying, geomagnetism, paleomagnetism, geoelectricity, gravity, wave propagation, time-series analysis, space applications of geophysics, tectonics, earth physics, and planetary sciences.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, and earth sciences; and at least 16 credits of intermediate-level work in any one or a combination of these subjects. Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field. There is no foreign language requirement for advanced degrees in geophysics.

GEOPHYSICS (GPHYS)

502. **SEISMIC INSTRUMENTS (3)** Characteristics and design of seismometers and seismic recorders.
504. **COMMUNICATION THEORY FOR GEOPHYSICISTS (3)** Basic theory of random processes leading to, and including, optimum filters; geophysical applications to gravity and seismic data analysis.
506. **MATERIAL PROPERTIES AND THE CONSTITUTION OF EARTH (3)** Application of the properties of materials to the composition and physical state of earth's crust, mantle, and core.
507. **SEISMOLOGY (3 per unit)**
Unit A. Basic theory; seismic methods for inferring structure of planetary interiors; observational techniques; seismic event location, magnitude, and damage potential.

Unit B. Advanced wave propagation theory; mathematical representation of seismic sources; inversion theory; computational methods.

- 508. TECTONICS (3) Seminar in the cause and nature of the principal deformations of the earth.
- 512. GRAVITY AND MAGNETICS (2) Advanced applied methods; application of filter theory and wavenumber domain analysis to data enhancement and interpretation. Prerequisite: Geosc. 487.
- 513. ELECTRICAL AND ELECTROMAGNETIC METHODS (2) Advanced applied techniques; theory and procedures for determining subsurface electrical conductivity.
- 514. SEISMIC METHODS (2) Advanced applied seismic techniques; application of linear system analysis to seismic reflection interpretation problems. Prerequisite: Geosc. 487.
- 515. ADVANCES IN EXPLORATION GEOPHYSICS (2) Special topics and new developments in exploration geophysics.
- 517. COMPUTATIONAL METHODS IN GEOPHYSICS (3) Practical methods of modeling geophysical phenomena for geologic structures; data analysis techniques; systematic inversion of geophysical data; special mathematical approximations.
- 521. THERMAL STATE OF THE EARTH (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

NOTE: See the *Geosciences (Geosc.) listing for 400-level Geophysics courses. Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Mineralogy.*

GERMAN (GER)

ERNST SCHÜRER, *Head of the Department*
S-323 Burrowes Building
814-865-5481

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Senior Members Ebbinghaus, Kopp, Preisner, and Schürer.

Graduate Faculty: Associate Members Browning, Keune, Martin, Strasser, and Ziegler.

There is opportunity for major emphasis upon literature, philology, or the teaching of German. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages.

Students may qualify for the M.A. and M.Ed. degrees either by writing a thesis — which is recommended if a student wishes to be considered for Ph.D. candidacy — or by submitting an essay to the department and taking additional 500-level German courses in lieu of 6 credits of thesis research.

Minimum qualifications for admission include 30 undergraduate credits in German beyond the intermediate level; provision is made, however, for admission with limited deficiencies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

GERMAN (GER)

- 401. ADVANCED COMPOSITION (3)
- 411. THE TEACHING OF GERMAN (3)

- 412. STRUCTURAL ANALYSIS OF MODERN GERMAN (3)
- 430. HISTORY OF THE GERMAN LANGUAGE (3)
- 440. GERMAN STUDIES (3)
- 443. (C.Lit. 443) LITERARY RELATIONS OF GERMANY WITH ENGLAND AND AMERICA (3-9)
- 445. THE VIKINGS (3)
- 450. MEDIEVAL GERMAN LITERATURE I (3)
- 451. MEDIEVAL GERMAN LITERATURE II (3)
- 452. LITERATURE OF THE RENAISSANCE (3)
- 460. LITERATURE OF THE BAROQUE (3)
- 461. LITERATURE OF THE ENLIGHTENMENT (3)
- 462. LITERATURE OF THE LATE EIGHTEENTH CENTURY (3)
- 470. GOETHE (3)
- 471. SCHILLER (3)
- 472. ROMANTICISM (3)
- 480. REALISM (3)
- 481. EARLY TWENTIETH CENTURY (3)
- 482. RECENT GERMAN LITERATURE (3)
- 496. INDEPENDENT STUDIES (1-12)

*1G. ELEMENTARY GERMAN FOR GRADUATE STUDENTS (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary German for Graduate Students (3) Continuation of Ger. 1G with opportunity for reading in special fields.

500. BIBLIOGRAPHY AND RESEARCH TECHNIQUES (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language.

520. INTRODUCTION TO MIDDLE HIGH GERMAN (3) Descriptive and historical grammar; readings in simple Middle High German texts.

521. READINGS IN MIDDLE HIGH GERMAN (3) Intensive reading in Middle High German literature, especially of the *Blütezeit*. Prerequisite: Ger. 520.

522. OLD HIGH GERMAN (3) Essentials of grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D.

523. GOTHIC (3) Introduction to historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English.

525. OLD ICELANDIC (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.

531. SEMINAR IN MEDIEVAL GERMAN LANGUAGES AND LITERATURES (3-6)

541. SEMINAR IN THE LITERATURE OF THE REFORMATION AND BAROQUE (3-6)

551. SEMINAR IN THE LITERATURE OF THE ENLIGHTENMENT AND THE AGE OF GOETHE AND SCHILLER (3-6)

561. SEMINAR IN POST-IDEALISTIC LITERATURE (3-6)

571. SEMINAR IN MODERN GERMAN LITERATURE (3-6)

581. SEMINAR IN LITERARY GENRES (3-12) Special studies in the German lyric, drama, short story, and novel.

591. SEMINAR IN GERMAN LITERARY CRITICISM (3)

*No graduate credit is given for this course.

595. INDEPENDENT STUDY (1-9) Selected projects in the study of German literature and philology. Prerequisite: Ger. 500.
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

HIGHER EDUCATION (HI ED)

JOHN HARDIN BEST, *In Charge of Graduate Programs in Higher Education*
319 Rackley Building
814-865-1487

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Eddy, Flexner, Godbey, Lindsay, Martorana, Mortimer, Sweitzer, and Toombs.

Graduate Faculty: Associate Members Moore and Tierney.

The graduate program in the higher education major has as its goal the preparation of individuals who will pursue careers as administrators, faculty, or researchers in the nation's colleges and universities and in a variety of public and private agencies and associations. With emphasis on the systematic study of higher education, the program builds on the scholarly and scientific disciplines offered throughout the University and applies these studies to the professional functions and responsibilities which its graduates will assume.

With mounting awareness of the need for educational reforms and for improved teaching, other departments throughout the University encourage their graduate students to pursue a minor in higher education. The higher education faculty cooperates in this program — which is administered through the students' major departments — by offering a number of courses and seminars designed to promote understanding of post-secondary teaching.

The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Those with a junior-senior average of 3.00, a graduate average of 3.50, and a standardized test score comparable to a 60 on the Miller Analogies Test (MAT) are usually admitted to the D.Ed. program. Applicants with a junior-senior average of 2.70, a graduate average of 3.20, and a MAT score of 50, and with special backgrounds, abilities, and interests will be considered for admission. Some outstanding students may be admitted to the doctoral program with only the baccalaureate degree, but they will earn the master's degree *en route*. For information about special requirements in the higher education major, write: Higher Education, The Pennsylvania State University, 319 Rackley Building, University Park, PA 16802.

HIGHER EDUCATION (HI ED)

460. (Ed.Ad. 460) INTRODUCTION TO ADULT EDUCATION (3)
545. HIGHER EDUCATION IN THE UNITED STATES (2-3) A basis for all courses in higher education. Current issues are analyzed and trends of the future anticipated.
546. COLLEGE TEACHING (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.
547. INTERNSHIP IN HIGHER EDUCATION (1-9) Supervised experience in administrative offices, in research, on instructional teams, and in college teaching.
548. CURRICULUMS IN HIGHER EDUCATION (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.
549. COMMUNITY JUNIOR COLLEGE AND THE TECHNICAL INSTITUTE (2-3) Distinctive contribu-

tions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration, and finance.

550. **THE PROFESSIONS AND THE EDUCATION OF TEACHERS (3)** The nature of a profession and dimensions of professional education in the United States are explored. Trends and issues examined.

552. **ADMINISTRATION IN HIGHER EDUCATION (2-3)** Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

554. **THE HISTORY OF AMERICAN HIGHER EDUCATION (3)** An examination of the development of American higher education against the background of influential social, political, economic, and intellectual issues.

556. **COLLEGE STUDENTS (3)** Characteristics of college students; changes during college years; educational challenges and responses. Prerequisite: Hi.Ed. 545 or Psy. 426 or I.F.S. 435.

575. (Ed.Ad. 575) **ADMINISTRATION OF ADULT EDUCATION (3)** The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Ad. 480 or teaching or administrative or supervisory experience.

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

HISTORY (HIST)

KENT FORSTER, *Head of the Department*
601 Liberal Arts Tower
814-865-1367

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Ameringer, Borza, Brown, Duiker, Eggert, Enteen, Forster, Frantz, Hassler, Maddox, Murray, Silverman, Sun, and Utechin.

Graduate Faculty: Associate Members Garner, Goldschmidt, Green, Griffith, Harvey, Knight, Linker, Meier, Spielvogel, Stebbins, and Sweeney.

Graduate work is offered in the following areas of history: ancient, medieval, Europe since 1500, Great Britain and the British Empire, Russia and Eastern Europe, the Middle East, the Far East, the United States, and Latin America. These areas are subdivided into chronological, national, and topical fields.

The candidate for the M.A. or M.Ed. degree selects one of the above areas for the master's examination. Some courses are required in an area in history other than the examination area and in a cognate field or archival option. (The cognate field for an M.Ed. candidate must be in education.) With the consent of the adviser, a master's candidate may substitute additional course work and a paper for a thesis.

The candidate for the doctor's degree must pass examinations in one of the above areas, in a thesis field within that same area, and in one field from a second area. The student must also pass an examination in a single cognate field, or in a study area made up of a number of academic disciplines related to the subject of the thesis. The communication and foreign language requirement for the Ph.D. may be satisfied by a reading knowledge of two foreign languages or one language and work in quantitative techniques. No foreign language is required for the D.Ed. degree, but the candidate must complete a minor in education.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of America from its discovery to the present. Students with a 3.00 junior-senior average and better than a 3.00 average in all undergraduate history courses and appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to

the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Each applicant must provide Graduate Record Examination scores and at least three letters of recommendation.

HISTORY (HIST)

401. CLASSICAL CIVILIZATION (3) *Borza and Harvey*
402. THE RISE OF THE GREEK POLIS (3) *Borza*
403. ALEXANDER THE GREAT AND THE HELLENISTIC WORLD (3) *Borza*
404. THE ROMAN REPUBLIC (3) *Harvey*
405. THE PAX ROMANA (3) *Harvey*
406. THE LATER ROMAN EMPIRE (3) *Harvey*
407. THE MIDDLE AGES FROM CONSTANTINE TO THE CRUSADES (3) *Sweeney*
408. THE MIDDLE AGES FROM THE CRUSADES TO THE RENAISSANCE (3) *Sweeney*
410. BYZANTINE CIVILIZATION (3)
411. HISTORY OF ENGLAND IN THE MIDDLE AGES (3) *Sweeney*
412. INTELLECTUAL HISTORY OF THE MIDDLE AGES (3) *Sweeney*
414. THE RENAISSANCE (3) *Spielvogel*
415. THE REFORMATION (3) *Spielvogel*
417. THE AGE OF ABSOLUTISM (3) *Green*
418. THE FRENCH REVOLUTION AND THE NAPOLEONIC ERA (3) *Green*
419. NINETEENTH-CENTURY EUROPE (3) *Rosenblatt*
420. RECENT EUROPEAN HISTORY (3) *Forster*
421. INTELLECTUAL AND CULTURAL HISTORY OF EUROPE, 1600-1800 (3) *Knight*
422. INTELLECTUAL AND CULTURAL HISTORY OF EUROPE SINCE 1800 (3) *Knight and Silverman*
423. SOCIAL AND ECONOMIC HISTORY OF EUROPE SINCE 1750 (3) *Silverman*
425. DIPLOMATIC HISTORY OF EUROPE SINCE 1870 (3) *Forster*
427. GERMANY SINCE 1640 (3) *Silverman*
428. FRANCE SINCE 1610 (3) *Knight*
430. EASTERN EUROPE IN MODERN TIMES (3) *Enteen*
432. HISTORY OF RUSSIA TO 1700 (3) *Utechin*
433. IMPERIAL RUSSIA, 1700-1917 (3) *Utechin*
434. HISTORY OF THE SOVIET UNION (3) *Enteen*
436. BRITAIN UNDER THE TUDORS AND STUARTS, 1485-1688 (3) *Linker*
437. GREAT BRITAIN, 1688-1832 (3) *Linker*
438. GREAT BRITAIN SINCE 1832 (3) *Linker*
440. COLONIAL AMERICA TO 1753 (3) *Frantz*
441. REVOLUTIONARY AMERICA, 1753-1783 (3) *Frantz*
442. THE FORMATIVE PERIOD OF AMERICAN HISTORY (3) *Brown*
443. THE MIDDLE PERIOD OF AMERICAN HISTORY (3) *Brown*
444. THE UNITED STATES IN CIVIL WAR AND RECONSTRUCTION (3) *Hassler*
445. THE EMERGENCE OF MODERN AMERICA (3) *Eggert*
446. AMERICA BETWEEN THE WARS (3) *Murray*
447. RECENT AMERICAN HISTORY (3) *Murray*
449. CONSTITUTIONAL HISTORY OF THE UNITED STATES TO 1877 (3) *Stebbins*
450. CONSTITUTIONAL HISTORY OF THE UNITED STATES SINCE 1877 (3) *Stebbins*
451. HISTORY OF AMERICAN POLITICAL PARTIES (3)
452. DIPLOMATIC HISTORY OF THE UNITED STATES TO 1900 (3) *Maddox*
453. THE DIPLOMATIC HISTORY OF THE UNITED STATES SINCE 1900 (3) *Maddox*
454. AMERICAN MILITARY HISTORY (3) *Hassler*
455. AMERICAN ECONOMIC HISTORY IN THE AGRICULTURAL ERA (3)
456. AMERICAN ECONOMIC HISTORY IN THE INDUSTRIAL ERA (3) *Eggert*
457. HISTORY OF THE AMERICAN FRONTIER (3)
458. (L.S. 458) HISTORY OF AMERICAN ORGANIZED LABOR SINCE 1877 (3) *Eggert*
459. SOCIAL AND CULTURAL HISTORY OF THE UNITED STATES SINCE 1783 (3) *Brown*
460. UNITED STATES FOREIGN INTELLIGENCE (3) *Ameringer*

464. SPANISH CONQUEST OF THE NEW WORLD (3) *Garner*
465. LATIN AMERICAN INDEPENDENCE MOVEMENTS (3) *Garner*
467. LATIN AMERICA AND THE UNITED STATES (3) *Ameringer*
468. MEXICO AND THE CARIBBEAN NATIONS IN THE TWENTIETH CENTURY (3) *Ameringer*
471. HISTORY OF ARABIC CIVILIZATION, 600-1258 (3) *Goldschmidt*
472. THE OTTOMAN EMPIRE AND OTHER MUSLIM STATES (3) *Goldschmidt*
473. THE CONTEMPORARY MIDDLE EAST (3) *Goldschmidt*
477. HISTORY OF CENTRAL AND EAST AFRICA (3) *Griffith*
478. HISTORY OF WEST AFRICA (3) *Griffith*
480. THE HISTORY OF TRADITIONAL JAPAN (3)
481. THE HISTORY OF MODERN JAPAN (3)
483. TRADITIONAL CHINA TO 1800 (3) *Sun*
485. NINETEENTH-CENTURY CHINA (3) *Sun*
486. TWENTIETH-CENTURY CHINA (3) *Duiker*
488. TWENTIETH-CENTURY SOUTHEAST ASIA (3) *Duiker*
490. (L.St. 490) ARCHIVAL MANAGEMENT. (1)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

501. HISTORICAL METHOD (3) *Meier and Utechin*
502. HISTORIOGRAPHY (3) *Borza and Meier*
503. STUDIES IN GREEK HISTORY (3-6) *Borza*
504. STUDIES IN ROMAN HISTORY (3-6) *Harvey*
509. MEDIEVAL CIVILIZATION (3-9) *Sweeney*
511. STUDIES IN MEDIEVAL ENGLISH HISTORY (3-6) A seminar in the political, economic, and cultural history of England in the Middle Ages.
515. THE AGE OF THE REFORMATION (3-6) *Spielvogel*
517. STUDIES IN EUROPEAN HISTORY, 1600-1750 (3-6) *Knight and Green*
519. STUDIES IN EUROPEAN HISTORY, 1750-1900 (3-6) *Knight and Silverman*
520. STUDIES IN TWENTIETH-CENTURY EUROPE (3-6) *Forster and Silverman*
530. SEMINAR IN EASTERN EUROPEAN HISTORY (3-6) *Enteen and Utechin*
533. STUDIES IN RUSSIAN AND SOVIET HISTORY (3-6) *Enteen and Utechin*
537. STUDIES IN BRITISH HISTORY (3-6) *Linker*
540. COLONIAL AND REVOLUTIONARY AMERICA (3-6) *Frantz*
543. THE UNITED STATES, 1783-1860 (3-6)
544. THE UNITED STATES, 1860-1877 (3-6) *Hassler*
545. THE UNITED STATES, 1877-1919 (3-6) *Eggert*
546. THE UNITED STATES SINCE 1919 (3-6) *Murray*
550. STUDIES IN CONSTITUTIONAL HISTORY (3-9) A graduate seminar examining constitutional developments in their historical context through readings, class discussions and research papers. *Stebbins*
553. DIPLOMATIC HISTORY OF THE UNITED STATES (3-6) *Maddox*
555. ECONOMIC HISTORY OF THE UNITED STATES (3-6) *Eggert*
559. CULTURAL HISTORY OF THE UNITED STATES (3-6) *Brown*
560. STUDIES IN PENNSYLVANIA HISTORY (3-6) *Frantz*
568. STUDIES IN THE HISTORY OF THE CARIBBEAN AREA (3 per term, maximum of 6) *Ameringer*

- 569. SEMINAR IN LATIN-AMERICAN HISTORY (3-6) *Ameringer*
- 573. STUDIES IN MIDDLE EASTERN HISTORY (3-6) *Goldschmidt*
- 583. STUDIES IN ASIAN HISTORY (3-9) *Sun and Duiker*
- 591. ARCHIVES PRACTICUM (3-6) Training and supervised work experience in archival activities — Option A: Archival Management; Option B: Oral History. Prerequisite: Hist. (L.St.) 490.
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

HOME ECONOMICS EDUCATION (HE ED)

TWYLA M. SHEAR, *In Charge of Graduate Programs in Home Economics Education*
212 Rackley Building
814-865-5441

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Murray, Ray, Shear, and Weis.

Graduate Faculty: Associate Member Thal.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

Students who have majored as undergraduates in some aspect of home economics and who have achieved a grade-point average of at least 2.50 in their junior and senior years will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Students wishing to be admitted to the doctoral programs must have completed a master's degree and will be admitted subject to limitations of departmental facilities. There is no foreign language requirement for degrees in the program.

HOME ECONOMICS EDUCATION (HE ED)

- 406v. AUDIO-VISUAL METHODS FOR HOME ECONOMICS (1-4)
- 427v. TEACHING HOME ECONOMICS (3)
- 463v. PRE-STUDENT-TEACHING SEMINAR (1)
- 464v. POST-STUDENT-TEACHING SEMINAR (1)
- 466v. STUDENT TEACHING (9)
- 477v. CURRICULUM DEVELOPMENT FOR HOME ECONOMICS IN SECONDARY SCHOOLS (3)
- 478v. APPRAISING STUDENT PROGRESS IN HOME ECONOMICS (3)
- 481v. EMPLOYMENT PREPARATION PROGRAMS IN VOCATIONAL HOME ECONOMICS (3)
- 482v. POSTSECONDARY, ADULT, AND CONTINUING EDUCATION PROGRAMS IN HOME ECONOMICS (3)
- 496v. INDEPENDENT STUDIES (1-12)
- 497v. SPECIAL TOPICS (1-6)

502, 502v. HOME ECONOMICS INSTRUCTION AT THE COLLEGE LEVEL (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers.

503, 503v. HOME ECONOMICS TEACHER EDUCATION (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics.

504, 504v. EDUCATIONAL ISSUES AND HOME ECONOMICS (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience.

510, 510v. **EDUCATIONAL LEADERSHIP IN HOME ECONOMICS (2-6)** Principles of educational leadership for home economists preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education major and two years' teaching experience in home economics.

511, 511v. **INTERNSHIP IN HOME ECONOMICS SUPERVISION AND ADMINISTRATION (2-8)** Opportunity to understudy an educational leader in student teacher supervision, state supervision, department or college administration, or regional consultation. Prerequisite: H.E.Ed. 510.

518, 518v. **EVALUATION OF HOME ECONOMICS PROGRAMS (3)** Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision.

521, 521v. **HOME ECONOMICS EDUCATION SEMINAR (2-3)** Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.

530, 530v. **PROBLEMS IN HOME ECONOMICS EDUCATION (1-6 per term)** Individual investigation of problems related to the teaching, supervision, or administration of home economics education.

577v. **CURRICULA IN HOME ECONOMICS (3)** Development of curricula in home economics. Prerequisite: H.E.Ed. 477v.

596v. **INDIVIDUAL STUDIES (1-6)**

597v. **SPECIAL TOPICS (1-6)**

602v. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

HORTICULTURE (HORT)

FRANCIS H. WITHAM, *Head of the Department*
103 Tyson Building
814-865-2571

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Beelman, Bergman, Craig, Garwood, Grun, Heuser, Mastalerz, McArdle, Ritter, Shannon, Smith, Stinson, Tukey, White, and Witham.

Graduate Faculty: Associate Members Beattie, Cole, Daniels, Haeseler, Haramaki, Holcomb, and Kuhns.

Students may specialize in several phases of production, plant genetics and breeding, soils and plant nutrition, horticultural physiology, post-harvest physiology, plant propagation, and microclimatology. Students wishing additional credits in the commodity areas of floriculture, olericulture, ornamental horticulture, and pomology, or in the areas of specialization listed above, should register for Hort. 596.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one of four options: (1) comprehensive competence in one language, (2) reading examination or two-course sequence in two languages, (3) reading examination or two-course sequence in one language plus 6 credits in other communications skills, or (4) 6 credits in each of two areas of communication skills.

Prerequisites for admission vary according to the area of specialization, but basic courses in physical sciences, mathematics, biological sciences, communication skills, and social sciences and humanities are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

HORTICULTURE (HORT)

401. **PLANT PROPAGATION (3)** *Haramaki*

402. **PLANT NUTRITION (3)** *Bergman*

403. **HORTICULTURE PLANTS AND THEIR ENVIRONMENT (3)** *Mastalerz*

405. SENIOR SEMINAR IN HORTICULTURE (1-2)
 407. PLANT BREEDING (3) *Garwood*
 412. POST-HARVEST PHYSIOLOGY (3)
 420. CHEMICAL GROWTH REGULATORS FOR HORTICULTURAL CROP PRODUCTION (3)
 421. PLANT TISSUE CULTURE (3)
 431. SMALL FRUIT CULTURE (3) *Daniels*
 432. DECIDUOUS TREE FRUITS (3) *Tukey*
 433. VEGETABLE CROP PRODUCTION (3) *Daniels*
 434. NURSERY CROP PRODUCTION (3) *Beattie*
 435. GREENHOUSE CROP PRODUCTION (3) *Holcomb*
 444. ADVANCED PLANT BREEDING (3-6) *Craig*
 451. FLOWER STORE MANAGEMENT (4) *Wolnick*
 452. GARDEN CENTER MANAGEMENT (3) *Wolnick*
 453. FLOWER CROP PRODUCTION AND MANAGEMENT (3) *Holcomb*
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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506. NUTRITION OF HORTICULTURAL CROPS (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Smith*
 512. PRINCIPLES OF FRUIT AND VEGETABLE STORAGE (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application.
 514. PROPAGATION AND IMPROVEMENT OF HORTICULTURE PLANTS (1-6) Biological factors affecting sexual and asexual propagation of plants; techniques in plant improvement; maintenance of propagation material. *Heuser*
 524. EXPERIMENTAL PROCEDURES IN HORTICULTURAL RESEARCH (3) *Craig*
 590. COLLOQUIUM (1-3)
 596. INDIVIDUAL STUDIES (1-6)
 597. SPECIAL TOPICS (1-6)
 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

HUMAN DEVELOPMENT AND FAMILY STUDIES (HD FS)

ROBERT L. BURGESS, *In Charge of Graduate Programs in Human Development and Family Studies*
S-107 Henderson Human Development Building
814-863-0241

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Baltes, Britton, Burgess, Danish, D'Augelli, de Lissovoy, Deutsch, Ford, Gottesman, B. Guernsey, L. Guernsey, Gunter, Hultsch, Huston, Knoll, Lerner, Liben, Nesselroade, Peters, Safilios-Rothschild, Spanier, Taylor, Urban, Vondracek, and Willis.

Graduate Faculty: Associate Members Anderson, Belsky, Getz, Goldberg, Hagestad, Hornblum, Lago, Madle, Nelson, Nottelman, Nowak, Schilmoeller, Seward, Smyer, Szinovacz, and Treat.

This interdisciplinary program is one of the graduate programs of the College of Human Development. It is administered through the program in Individual and Family Studies. Human development and family studies focuses on the developmental study of individuals, small groups, and families for the purposes of expanding basic knowledge and professional application. The perspective encompasses the individual life span, from infancy and childhood through later maturity and old age, as well as the full cycle of the family. For both individual and family, the perspective includes variations in functioning patterns and the use of resources; the impact of diverse social, economic, and cultural contexts upon behavior; conditions which promote adaptive individual, group, and family development; and the crea-

tion of techniques of accomplishing human development. Emphasis is upon the integration of knowledge from various fields for understanding and developing skills for careers in research and scholarship, teaching, program planning and evaluation, and other professional services. The faculty includes persons primarily in the behavioral and social sciences particularly committed to research and application in these multi- and interdisciplinary areas.

The student's program is expected to include work assuring both breadth in the major field and depth within one of three program areas: family development, human development intervention, or individual development. Further specialization is possible in adult development and aging, child and adolescent development, early childhood services, interpersonal relations, family economics and management, and family relationships.

Infant and early childhood laboratories are operated as part of the teaching and research program. Each unit has observational facilities and rooms for study of individual and group behavior of children and adults. The Individual and Family Consultation Center provides facilities for the development and evaluation of educational programs for remediation of individual and family problems by professional and paraprofessional persons. The Institute for the Study of Human Development, the Center for Health and Human Services, the Gerontology Center, the Center for Children, Youth, and the Family, and the Center for Community Research provide opportunities for participation in research and evaluation projects. Additional resources are available in other parts of the University.

A research and evaluation methodology core, required of all students, may be satisfied by selections from a variety of courses across the campus. Use may be made also of courses in other parts of the college and University to build substantive competence in the program. The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages. A minor or general studies group outside the major is required of all doctoral students.

Entering students should have at least 6 credits in the biological and physical sciences; 12 in the social sciences and, depending upon proposed area of emphasis, basic courses in sociology, psychology, and economics; and 6 in developmental and family studies. Students not meeting these requirements may be admitted with limited deficiencies to be made up concurrently with their graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission, which, with rare exception, will be for fall term only. Early application is required, and a special application to HDFS must be completed; additional information may be obtained from the professor in charge. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. The Graduate Record Examination is required of all applicants.

INDIVIDUAL AND FAMILY STUDIES (I F S)

- 410. COMMUNITIES AND FAMILIES (3)
- 411. THE HELPING RELATIONSHIP (3)
- 412. ADULT-CHILD RELATIONSHIPS (3)
- 413. DYSFUNCTIONS IN THE DEVELOPMENTAL PROCESS (3)
- 414. RESOLVING INDIVIDUAL AND FAMILY PROBLEMS (3)
- 415. PROGRAM DEVELOPMENT IN FAMILY RELATIONSHIPS (3)
- 416. (C.S. 416) CONSUMER ROLE OF FAMILY (3)
- 418. FAMILY RELATIONSHIPS (3)
- 419. PROBLEMS OF FAMILY FINANCIAL MANAGEMENT (3)
- 420. LABORATORY IN INDIVIDUAL AND FAMILY ENHANCEMENT (3)
- 424. ECONOMIC CONDITIONS IN RELATION TO THE FAMILY (3)
- 427. CONCEPTIONS OF DEVELOPMENT (3)
- 428. INFANT DEVELOPMENT (3)
- 429. ADVANCED CHILD DEVELOPMENT (3)
- 430. PRACTICUM IN PRESCHOOL GROUPS (1-6)
- 432. DEVELOPMENTAL PROBLEMS OF NORMAL CHILDREN (3)
- 435. DEVELOPMENTAL TRANSITION TO ADULTHOOD (3)
- 442. HOME MANAGEMENT EXPERIENCE (3)
- 445. (Psy. 445) DEVELOPMENT THROUGHOUT ADULTHOOD (3)-

450. IMPLICATIONS OF DEVELOPMENTAL THEORIES FOR CHILD PROGRAMS AND SERVICES (3)
453. CHILD PROGRAMS AND SERVICES (3)
454. (C.&S. 454) DEVELOPMENT AND ADMINISTRATION OF CHILD SERVICE PROGRAMS (3)
470. (Psy. 470) SOCIAL LEARNING FOUNDATIONS OF BEHAVIOR CHANGE (3)
477. ANALYSIS OF FAMILY PROBLEMS (2-9)
490. INTRODUCTION TO FIELD EXPERIENCE (1)
491. DESIGN OF FIELD RESEARCH PROJECTS (2)
492. ADVANCED FIELD EXPERIENCE (1-10)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. NONTHESIS RESEARCH (1-9)
501. SEMINAR: ISSUES IN THE STUDY OF INDIVIDUAL AND FAMILY DEVELOPMENT (1-3) Reading, reports, and discussion of conceptual frameworks for multidisciplinary and developmental study of individuals and families.
504. PRACTICUM IN PROGRAM DEVELOPMENT FOR PRESCHOOL CHILDREN (2-6) Investigation, analysis, and report on the design, development, and evaluation of a selected program for preschool children. Prerequisites: 6 credits of individual development and I.F.S. 430, 441.
506. PROJECTS IN DESIGN AND EVALUATION OF PROGRAMS FOR PRESCHOOL CHILDREN (2-4) Individual projects in the design, implementation, and evaluation of different teaching approaches with varying groups of children. Prerequisites: I.F.S. 504 and 3 credits in research methods.
508. PARENTAL EDUCATION (1-6) Implementing educational and preventive programs for parents; discussion and evaluation of theory and techniques.
511. MODIFYING CONJUGAL LIFE (1-9) Conceptual foundations, research procedures, and practicum experience in teaching effective communication and problem-solving skills in the marriage relationship. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.
512. FILIAL RELATIONSHIP MODIFICATION (1-9) Theory, research, and practicum in teaching parents to resolve developmental problems in their own children. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.
513. GROUP PROCEDURES IN INDIVIDUAL DEVELOPMENT (1-6) Theory, research, and practicum experience in the use of group methods for promoting individual development in different age groups. Prerequisites: I.F.S. 411 and research methods or statistics.
515. TEACHING INDIVIDUAL DEVELOPMENT AND FAMILY STUDIES (1-6) Objectives, techniques, materials, and evaluation in teaching at the secondary and college level, and in adult and public education programs.
520. SEMINAR IN PRENATAL AND INFANT DEVELOPMENT (1-6) Prenatal and infant development, with emphasis on multiple determinants of early development and their relationship to later behavior. Prerequisites: 6 graduate credits in individual development, psychology, or biological science and 3 credits in statistics.
522. SEMINAR IN DYSFUNCTION PROCESSES IN INDIVIDUAL DEVELOPMENT (1-6) Multiple processes involved in dysfunctional development in the individual across the life-span. Prerequisite: I.F.S. 413.
524. THEORETIC ANALYSIS OF FAMILY ECONOMIC AND MANAGERIAL BEHAVIOR (3) Conceptual approaches and major contributions to the study of the organizational, managerial, and economic functions of the family. Prerequisite: I.F.S. 418 or 424 or 477.
525. THEORIES OF FAMILY RELATIONSHIPS (3) Assessment of the utility of major theories for empirical analysis of interpersonal interactions among family members. Prerequisite: I.F.S. 418.
529. (Psy. 529) SEMINAR IN CHILD DEVELOPMENT (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

530. **INDEPENDENT STUDY IN INDIVIDUAL AND FAMILY STUDIES (1-9)** Problems involving individual study. Prerequisite: instructor's approval of proposed study.
532. **FIELD PROJECTS IN INDIVIDUAL AND FAMILY STUDIES (1-9)** Supervised research or internship in human services program. Prerequisite: instructor's approval of proposed project.
536. (Psy. 536) **RESEARCH METHODS IN DEVELOPMENTAL PROCESSES (3)** Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology and a course in statistics.
539. **SEMINAR IN ADOLESCENT DEVELOPMENT (1-6)** Cultural, psychological, and biological aspects of the developmental transition to adulthood. Prerequisites: 6 credits in individual development or psychology and 3 credits in sociology and statistics.
543. **MODIFICATION OF FAMILY MANAGERIAL PRACTICES (1-3)** Conceptual issues, research, and practicum experience in assisting families in the solution of financial and managerial problems.
544. **SEMINAR IN DYSFUNCTIONAL PATTERNS IN FAMILY ORGANIZATION (1-6)** Processes of familial dysfunction and disorganization and their explanation in economic, social-psychological, and managerial terms. Prerequisite: I.F.S. 418 or 424 or Soc. 430.
545. **FAMILIES AND SOCIOECONOMIC SYSTEMS (1-6)** Functional interrelationships between families and social and economic systems. Prerequisites: I.F.S. 418, 424.
546. **SEMINAR IN FAMILY RELATIONSHIPS (1-9)** Interpersonal interaction within family systems throughout the life cycle. Prerequisite: I.F.S. 418.
549. (Psy. 549) **DEVELOPMENTAL THEORY (3)** Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.
550. **SEMINAR IN FAMILY ECONOMICS AND MANAGEMENT (1-6)** Recent developments in the study of family economic and managerial practices.
579. **SEMINAR IN ADULT DEVELOPMENT AND AGING (1-9)** A seminar dealing with specific topics concerning adult development and aging. Prerequisites: I.F.S. 445 and statistics.
590. **COLLOQUIUM (1-3)**
597. **SPECIAL TOPICS (1-6)**

HUMANITIES (HUMAN)

ROBERT J. GRAHAM, *Program Head, Humanities*
The Capitol Campus, Middletown, PA 17057
717-948-6189

Degree Conferred: M.A.

Graduate Faculty: Senior Members Dordevic, R. Graham, Gross, Richman, Tischler, G. Wolf, and M. Wolf.

Graduate Faculty: Associate Members Churchill, T. Graham, Mahar, Patterson, and K. Sweeney.

Defining humanities as the study of men and societies through examinations of their arts, this program aims at developing skills for the interdisciplinary study of art, music, literature, philosophy, and related fields such as photography, film, dance, and theater. Entering students are expected to have studied in at least two of the major areas. Exceptions may be made for students with special backgrounds and abilities who are committed to attaining competence in a second area. A supervisory committee meets with each student to determine individual needs and arrange a program designed to develop skills for the formal analysis of works; for analysis based on various critical perspectives; for evaluation of works by applications of appropriate criteria; and for the perception of relationships between styles, media, periods, and cultures. For students who plan to teach in a junior or community college, there is also provision for an internship option following the completion of most degree requirements.

A series of six 500-level courses is designed to help a student develop a number of the program skills. In addition, the adviser may suggest enrollment in certain 400-level courses or in independent studies with qualified faculty. The degree program requires completion of 18 credits at the 500 level.

To qualify for the M.A. in humanities, the student must demonstrate competence in applying the methods of humanistic inquiry to a relevant subject area. Course work and independent study will help in the development of the appropriate skills and the acquisition of necessary knowledge, but the degree is not awarded in recognition of a set total number of course credits having been compiled; the degree testifies that the recipient has cultivated the necessary skills of analysis and synthesis and has successfully completed a scholarly or creative master's production.

Ordinarily, a full-time student can expect to complete the program in four terms, a part-time student in six to nine terms.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is available only at the Capitol Campus.

HUMANITIES (HUMAN)

500. RESEARCH METHODS (3) Study of the methods and materials of scholarship, compilation of bibliographies, writing of scholarly papers, and proper documentation.

502. PERENNIAL ISSUES IN THE HUMANITIES (3) Recurrent issues viewed in terms of their significance to the artist, historian, and the philosopher.

503. INTERRELATIONS IN THE HUMANITIES (3) An interdisciplinary study of the interdependence of aesthetic values in various art forms as they exist in cultural settings. Prerequisite: Human. 500.

520. STUDIES IN STYLE (3) Study of prominent stylistic patterns, evaluating the essence of a style, and the varied responses of the artist and philosopher within a pattern.

525. STUDIES IN AESTHETICS (3) Study of certain techniques in the arts that presuppose certain aesthetic concepts and certain ideas that demand parallel form.

580. MASTER'S PRODUCTION (1-6) An original scholarly master's paper or creative production initiated by the student, supervised by an appropriate professor, and judged by a committee.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

Additional courses may be taken from the following list and at the 400- or 500-level in related fields with the concurrence of the student's adviser.

AM.ST. 445. AMERICAN PHILOSOPHY

AM.ST. 452. THE AMERICAN RENAISSANCE

AM.ST. 455. AMERICAN PHILOSOPHY

AM.ST. 459. AMERICA'S COMING OF AGE 1914-1939

AM.ST. 460. AMERICAN ART AND ARCHITECTURE

AM.ST. 461. AMERICAN ART AND ARCHITECTURE OF THE NINETEENTH CENTURY

AM.ST. 463. AMERICAN MUSIC

ART 415. STUDIO ART

ART 420. CRITICAL APPROACHES TO ART

ART 427. MASTERS OF ART

ART 440. TOPICS IN ART

HUMAN. 405. THE STUDY OF INTELLECTUAL AND CULTURAL HISTORY

HUMAN. 408. COMPARATIVE STUDY OF RELIGIOUS LITERATURE

HUMAN. 409. MYTH AND CHILDREN'S LITERATURE

HUMAN. 410. RELIGION AND LITERATURE

- HUMAN. 430. PHILOSOPHY AND LITERATURE
- HUMAN. 441. MYTH, SYMBOL, AND RITUAL
- HUMAN. 453. LITERATURE AND SOCIETY
- HUMAN. 460. THEMATIC STUDIES
- HUMAN. 461. SELECTED PERIODS IN THE HUMANITIES
- LIT. 427. MASTERS OF LITERATURE
- LIT. 440. FORM AND FUNCTION
- LIT. 450. CULTURAL PATTERNS IN LITERATURE
- LIT. 460. LITERARY PERIODS
- LIT. 461. STUDIES IN LITERARY STYLE
- MUSIC 427. MASTERS OF MUSIC
- MUSIC 440. FORMS IN MUSIC
- MUSIC 460. STUDIES IN MUSICAL STYLE
- O.S. 410. CHINESE PHILOSOPHY AND WESTERN THOUGHT
- O.S. 455. ORIENTAL CULTURE
- PHIL. 415. AESTHETICS
- PHIL. 431. PHILOSOPHICAL PERSPECTIVES
- PHIL. 440. READING OF AN INDIVIDUAL PHILOSOPHER
- PHIL. 445. SOCIAL-POLITICAL PHILOSOPHIES
- PHIL. 447. PHILOSOPHICAL PERIODS
- PHIL. 490. PHILOSOPHICAL TOPICS
- THEA. 406. STUDIES IN THEATRE
- ED. 520. SEMINAR IN JUNIOR COLLEGE TEACHING
- ED. 550. INTERNSHIP IN JUNIOR COLLEGE

INDUSTRIAL ENGINEERING (I E)

WILLIAM E. BILES, *Head of the Department of Industrial and Management Systems Engineering*
 207 Hammond Building
 814-865-7601

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Biles, Callahan, Draper, Ensore, Guild, Ham, Ignizio, Raphael, and Rosenshine.

Graduate Faculty: Associate Members Anderson, Davis, Freark, Fugelso, Garber, Goodrich, Kozik, Pegden, Thuerling, and Zindler.

Graduate study and research are conducted in operations research-management science, production engineering, process design, systems engineering, and human engineering.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of one foreign language (Russian, German, French, or Japanese).

Graduates in industrial engineering, other engineering curriculums, and mathematics who present a 2.50 junior-senior average will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 239).

INDUSTRIAL ENGINEERING (I E)

- 400. ENGINEERING FOR PRODUCTION (3)
- 401. WORK MEASUREMENT APPLICATIONS (3)
- 402. ENGINEERING ECONOMY (3)
- 403. ENGINEERING ECONOMY AND STATISTICS (3)

- 404. MANAGEMENT SCIENCE (3)
- 405. LINEAR PROGRAMMING (3)
- 406. DESIGN OF PRODUCTION AND DISTRIBUTION SYSTEMS (3)
- 407. QUANTITATIVE METHODS FOR OPERATIONS RESEARCH (3)
- 408. HUMAN FACTORS ENGINEERING (3)
- 414. MATERIALS JOINING PROCESSES AND PRINCIPLES (3)
- 423. QUALITY CONTROL (3)
- 424. PROBLEMS IN PERSONNEL MANAGEMENT (3)
- 425. INTRODUCTION TO OPERATIONS RESEARCH (3)
- 426. INDUSTRIAL AUTOMATION (3)
- 427. SOLIDIFICATION OF CASTINGS (3)
- 428. FOUNDRY ENGINEERING (3)
- 432. INTRODUCTION TO RELIABILITY ENGINEERING (1-3)
- 438. METAL CUTTING PRINCIPLES AND PRACTICE (3)
- 439. ENGINEERING SYSTEMS OPTIMIZATION (3)
- 450. MANUFACTURING SYSTEMS ENGINEERING (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. MANUFACTURING METHODS (2-8) Special projects including investigation, experimentation, design, and research of one or more special types of manufacture.
- 503. INDUSTRIAL RELATIONS (1-6) Study of human problems related to labor unions, hierarchy, specialization; analysis of organizational structure, policies, decision criteria, and communication systems.
- 506. ADVANCED WORK DESIGN AND MEASUREMENT (3-9) Methods of research in motion and time study; critical analysis of current literature.
- 507. OPERATIONS RESEARCH: SCHEDULING MODELS (3) Scheduling models with simultaneous job arrival and probabilistic job arrival, network scheduling and scheduling simulation techniques. Prerequisite: I.E. 425.
- 508. OPERATIONS RESEARCH: INVENTORY MODELS (3) A study of inventory theory, deterministic models, probabilistic models, multiproduct models in both the single and multiperiod modes. Prerequisite: I.E. 425.
- 509. OPERATIONS RESEARCH: WAITING LINE MODELS (3) Waiting line models including models with infinite queues, finite queues, single and multiple servers under various priorities and disciplines. Prerequisite: I.E. 425.
- 510. MATHEMATICAL PROGRAMMING (3) Study of advanced topics in linear programming including duality, decomposition, sensitivity analysis, parametric programming, and selected topics in mathematical programming. Prerequisite: I.E. 405.
- 511. EXPERIMENTAL DESIGN IN ENGINEERING (3) Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisite: I.E. 323.
- 512. GRAPH THEORY AND NETWORKS IN MANAGEMENT SCIENCE (3) Prerequisite: I.E. 425.
- 513. REAL TIME DATA PROCESSING FOR ENGINEERING SYSTEMS (3) Random access computers and communication components for real time systems; engineering systems simulation on digital computers. Prerequisite: Cmp.Sc. 102 or 410.
- 515. COMPLEX LINEAR FLOW MODELS (3) Application of complex linear flow models in engineering and management science, including static and dynamic system simulations. Prerequisite: I.E. 405.
- 516. APPLIED STOCHASTIC PROCESSES I (3) Prerequisite: Stat. (Math.) 427.
- 518. PLASTIC DEFORMATION PROCESSES (3) Study of the principles, theories, technology, design,

and application of plastic deformation processes to shape metals. Prerequisite: undergraduate engineering degree.

519. **DYNAMIC PROGRAMMING (3)** Study of the concepts underlying model-building and optimization of dynamic systems with application to engineering, economic, and environmental systems. Prerequisites: I.E. 405 or Q.B.A. 451; Stat. 418.

520. **GOAL PROGRAMMING (3)** Study of concepts and methods in analysis of systems involving multiple objectives with applications to engineering, economic and environmental systems. Prerequisite: I.E. 405 or Q.B.A. 451.

521. **ENGINEERING SYSTEMS OPTIMIZATION (3)** Fundamental theory of optimization, including classical optimization, search methods, functional optimization; with engineering applications as industrial, mechanical, and chemical processes. Prerequisites: Math. 260 and FORTRAN programming ability.

522. **INDUSTRIAL SYSTEMS SIMULATION (3)** Study of discrete-event, network, and continuous simulation of industrial and manufacturing systems using the SLAM/GASP-IV languages; statistical techniques in simulation methodology. Prerequisites: I.E. 322 and FORTRAN programming ability.

528. **METAL CUTTING THEORY (3)** Study of the theory of metal cutting, contemporary and future problems of metal removal processes; critical analysis of current literature. Prerequisite: I.E. 438.

538. **EXPERIMENTAL INVESTIGATIONS IN MATERIALS PROCESSING (3)** Experimental investigation on selected subjects in processing involving instrumentation, methods, and analysis. Prerequisite: I.E. 528.

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

JOURNALISM (JOURN)

DANIEL W. PFAFF, *In Charge of the Graduate Program in Journalism*
218 Carnegie Building
814-863-0506

Degree Conferred: M.A.

Graduate Faculty: Senior Members Blanchard and Smith.

Graduate Faculty: Associate Members Berner, Dulaney, Froke, Goodwin, McGlashan, Nichols, Norris, Pfaff, Rippey, and Tenney.

The one-year program is intended to serve two kinds of students: those who enter with several years of media work experience who are interested in improving their job marketability or in broadening the range of their professional abilities, and those with little or no media experience who are interested in preparing for a career in journalism. Experienced persons will be required to earn from 30 to 33 credits in prescribed course work and electives. Those without experience will take 33 to 36 credits of course work and electives. Experienced persons will have more latitude in course selection than those without experience. In individual cases, it may be possible for a candidate to take up to 9 credits of work outside the School of Journalism. In all cases, the program must be substantially completed in twelve months.

Students with a 3.00 junior-senior average are eligible for admission. Those with lower averages who have significant professional experience or other unusual qualifications also will be considered. Two letters of recommendation are required. They should be from persons closely familiar with the applicant's professional background and competencies. The Graduate School requires all applicants to submit copies of their Graduate Record Examination scores. Applicants must submit an autobiographical statement of about 1,000 words indicating the nature of the applicant's interest in journalism or mass communications, reasons for wanting to do graduate work, and aspirations for the future.

JOURNALISM (JOURN)

401. MASS MEDIA IN HISTORY (3)
 403. LAW OF MASS COMMUNICATIONS (3)
 405. POLITICAL ECONOMY OF COMMUNICATIONS (3)
 407. ADVERTISING IN CONTEMPORARY SOCIETY (3)
 409. CRITICS AND ETHICS OF THE MASS MEDIA (3)
 411. CULTURAL ASPECTS OF THE MASS MEDIA (3)
 413. THE MASS MEDIA AND THE PUBLIC (3)
 415. CURRENT ISSUES IN ADVERTISING (3)
 416. (Engl. 416) SCIENCE WRITING (3-6)
 417. ADVERTISING AND CONSUMERISM (3)
 419. (Sp.Com. 419) COMPARATIVE BROADCASTING SYSTEMS (3)
 421. PUBLIC AFFAIRS REPORTING (3)
 423. REPORTING OF CONTEMPORARY ISSUES (3)
 425. NEWS EDITING AND EVALUATION (3)
 426. REPORTING BUSINESS AND ECONOMIC NEWS (3)
 427. MAGAZINE JOURNALISM (3)
 429. EDITORIAL INTERPRETATION (3)
 436. (Soc. 436) SOCIOLOGY OF OPINION FORMATION (3)
 441. ADVERTISING COMMUNICATIONS PROBLEMS (3)
 443. ADVERTISING MEDIA PLANNING (3)
 445. ADVERTISING CAMPAIGNS (3)
 451. PUBLIC RELATIONS (3)
 453. PUBLIC RELATIONS PROBLEMS (3)
 461. PHOTOGRAPHY FOR THE MASS MEDIA (3)
 473. INTERNATIONAL MASS COMMUNICATIONS (3)
 475. EVALUATION AND USES OF MASS COMMUNICATIONS RESEARCH (3)
 477. JOURNALISM IN THE SCHOOLS (3-6)
 485. INTERNSHIP (1-9)
 487. (Sp.Com. 487) MASS COMMUNICATIONS STUDY ABROAD (1-9)
 492. PUBLIC AFFAIRS BROADCASTING (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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504. SEMINAR IN THE HISTORY OF MASS COMMUNICATION (3)
 505. INTERNATIONAL COMMUNICATION PROBLEMS (3) Legal and communications problems of the international flow of news and opinion; international press codes.
 506. INTRODUCTION TO MASS COMMUNICATIONS RESEARCH (3) The scientific method; survey of basic concepts of theoretical and empirical research; variety of methodology; criteria for adequate research.
 508. THE LITERATURE OF JOURNALISM (3)
 511. MASS COMMUNICATIONS RESEARCH METHODS II (3) Problems of bibliographical research; evaluation of sources and materials in mass communications history, biography, structure, ethics, and other areas. Prerequisite: Journ. 506.
 513. CONSTITUTIONAL PROBLEMS OF THE NEWS MEDIA (3) Problems involving conflict between guarantees of press freedom in the First and Fourteenth Amendments and rights and privileges of others.
 521. NEWS MEDIA AND PUBLIC OPINION (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion.
 524. GOVERNMENT AND MASS COMMUNICATIONS (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Smith*

- 540. SEMINAR IN ADVERTISING PROBLEMS (3) *Norris*
- 585. COMPARATIVE THEORIES OF PRESS SYSTEMS (3) Institutional structure and normative functions of press systems in modern societies, as shaped by prevailing world view and social organization. *Norris*
- 596. INDIVIDUAL STUDIES (1-6)-
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

LABORATORY ANIMAL MEDICINE (L A M)

C. MAX LANG, *Chairman of the Department of Comparative Medicine*
 The Milton S. Hershey Medical Center
 Hershey, PA 17033
 717-534-8460

Degree Conferred: M.S.

Graduate Faculty: Senior Members Bullock and Lang.

Graduate Faculty: Associate Members Hughes and White.

The department offers a postdoctoral program for veterinarians leading to the Master of Science degree with a major in laboratory animal medicine. Laboratory animal medicine is a specialty of veterinary medicine that is concerned with the biology of laboratory animals and their comparative relationships to man. Postdoctoral training in this discipline provides a broad, basic foundation upon which the individual can build a career in teaching and research in laboratory animal medicine and/or in the professional direction of research animal facilities. The program has a strong research-oriented base with emphasis on comparative medicine and pathology.

The program requires two years for completion. Basically, the first year consists of formal course work, while the second year is devoted mainly to research and the development of clinical skills and techniques. A student must have earned a minimum of 12 credits in a major subject, 6 credits in a minor subject, and 6 credits of thesis research in order to receive the graduate degree. Approved minors have been established in anatomy, behavioral science, biological chemistry, microbiology, pathology, pharmacology, and physiology.

Students with a 3.00 junior-senior average, with a doctor of veterinary medicine degree, and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is offered only at The Milton S. Hershey Medical Center.

COMPARATIVE MEDICINE (C MED)

501. BIOLOGY AND CARE OF LABORATORY ANIMALS (2) Presentation of the anatomic and physiologic characteristics of the commonly used laboratory animal species and their relation to biomedical research.

503. LABORATORY ANIMAL GENETICS (2) Genetic principles applied to laboratory animals used for investigations of diseases that may be controlled or influenced by genetic factors.

505. LABORATORY ANIMAL ZOOSES (2) Experimentally induced, spontaneous, and infectious diseases transmissible between man and animals, with special emphasis on etiology, differential diagnosis, and control.

507. TECHNIQUES OF LABORATORY ANIMAL EXPERIMENTATION (2) Techniques of drug administration, infusion, and collection of body fluids and materials; gnotobiology; use of radioisotopes and bioinstrumentation.

- 510. ANIMAL PHYSIOLOGICAL SURGERY (3) Selected operative procedures, demonstrating principles of physiology with modern biomedical instrumentation, will be followed through the postoperative period.
- 515. EXPERIMENTAL SURGERY OF LABORATORY ANIMALS (3) Surgical techniques, including nephrectomy and Goldblatt clamp, bladder and gastric pouches, bile duct cannulation, intraventricular operation, cardiac and cerebrovascular catheterization.
- 530. DISEASES OF LABORATORY ANIMALS I (3) Physiological and pathological expressions of both infectious and metabolic-degenerative diseases of rodents, with emphasis on diagnostic and control methods.
- 531. DISEASES OF LABORATORY ANIMALS II (3) Physiological and pathological expressions of both infectious and metabolic-degenerative diseases of nonhuman primates and other species of animals.
- 535. COMPARATIVE PATHOLOGY (3) Comparative pathologic characteristics of infectious and metabolic disease of animals and man.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

LINGUISTICS (LING)

PHILIP BALDI, *In Charge of Graduate Programs in Linguistics*
 310 Burrowes Building
 814-865-6873

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Baldi, Belasco, Brault, Brubaker, Dalbor, Ebbinghaus, Holtzman, Magner, Martin, Morrill, Palermo, Schmalstieg, and Sturcken.

Graduate Faculty: Associate Members Buckalew and Smaby.

A student majoring in linguistics may specialize in one of several flexible interdisciplinary graduate programs. The M.A. degree program includes general courses in historical linguistics, generative phonology and syntax, psycholinguistics, and acoustic phonetics. A candidate will also select, with the help of the graduate adviser, a coherent set of electives in a specialized area which may be a language or a related field. An acceptable thesis or paper must be submitted and a written comprehensive examination passed.

In addition to the courses required for the M.A. degree in linguistics (or the equivalent), each candidate for the Ph.D. degree must take the following courses: Ling. 503 if Ling. 504 is selected; Ling. 505 (Seminar in Historical Linguistics), Sp.Com. 520 (Seminar in Speech Science), and at least two 500-level courses in the structure, phonology, and history of a language or language family other than the native language if the specialty is in a related area, and at least five 500-level courses in the related area. If the specialty is in a language area, the student must take at least two 500-level courses in the structure, phonology, and history of a language or language family other than the native language or language area and at least five 500-level courses in the chosen language area. The specialized area will be selected by the candidate with the approval of the doctoral committee. The doctoral comprehensive examinations will be both written and oral and will cover the synchronic and diachronic aspects of general linguistics as well as the candidate's specialized area. The thesis must represent a significant contribution to linguistic knowledge. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of either French, German, Spanish, or Russian, and another major language related to the candidate's professional interests.

The minimum requirement for admission to an advanced degree program will normally be a B.A. degree in linguistics or an equivalent in any of the interdisciplinary subjects recognized as a specialized area.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

LINGUISTICS (LING)

- 400. INTRODUCTION TO TRANSFORMATIONAL GRAMMAR (3)
- 401. INTRODUCTION TO LINGUISTIC THEORIES (3)
- 402. HISTORICAL LINGUISTICS (3)
- 404. GENERATIVE PHONOLOGY (3)
- 413. (Sp.Com. 413) EXPERIMENTAL LINGUISTICS (3)
- 415. CONTRASTIVE ANALYSIS (3)
- 420. (Psy. 420) ADVANCED PSYCHOLINGUISTICS (3)
- 448. LANGUAGE VARIATION (3)
- 449. PROBLEMS IN TRANSFORMATIONAL SEMANTICS (3)
- 461. (Latin 461) HISTORY OF THE LATIN LANGUAGE (3)

- 500. GENERATIVE LINGUISTICS (3) Types of grammatical rules and their interrelations; algorithm for assigning structural descriptions; evaluation procedure for selecting best compatible grammar.
- 503. GENERATIVE SYNTAX (3) Grammatical rules specifying well-formed strings; conditions on analyzability and assigning of structural descriptions; deviation from well-formedness. Prerequisite: Ling. 400.
- 504. GENERATIVE PHONOLOGY (3) Distinctive feature theory in the generative framework; articulatory and acoustic correlates; nonphonemic features. Prerequisite: Ling. 400.
- 505. SEMINAR IN HISTORICAL LINGUISTICS (3) Detailed study of some problem of historical linguistics, e.g., the laryngeal theory, Indo-European ablaut, etc. Prerequisite: one course in historical linguistics.
- 517. (S.P.A. 517) APPLICATIONS OF LINGUISTICS TO COMMUNICATION DISORDERS (1) Application of linguistic theory to the understanding of communication disorders, with clinical implications for speech and language therapy. Prerequisites: 12 credits in speech pathology and audiology, psychology, linguistics, or phonetics.
- 520. (Psy. 520) SEMINAR IN PSYCHOLINGUISTICS (3) Consideration of theoretical and research issues relevant to psychological aspects of language sounds, syntax and semantics, and other cognitive support.
- 595. SEMINAR IN INTERDISCIPLINARY LINGUISTICS (3-12) Methods of research. Common and individual investigations in interdisciplinary fields of linguistics in consultation with one or more interdisciplinary instructors. Prerequisite: Ling. 400.
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

MAN-ENVIRONMENT RELATIONS (M E R)

STUART H. MANN, *Program Head*
S-126 Henderson Human Development Building
814-865-1467

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Everett, Lawton, Mann, Patterson, Powers, Studer, Vallance, and Wohlwill.

Graduate Faculty: Associate Members Cohn, Griffin, Loukissas, and Weisman.

The program in Man-Environment Relations has two degree programs, one leading to the Ph.D. degree in man-environment relations and the other to the D.Ed. degree in food service management.

The objective of the Ph.D. degree program in man-environment relations is to seek, through a broad-based analysis of complex environmental problems, an integrated understanding of man-environment systems, and to develop appropriate methods to plan and manage these systems. The multidisciplinary program is concerned with the analysis of the effects of the physical environment upon human psychological, social, and biological functioning, and with the development of methods for organizing planned systems in response to social and behavioral goals. The research and instructional activities in the program focus on: (1) the relation of behavior to characteristics of environmental settings such as schools, housing and recreational facilities, and urban neighborhoods and communities; (2) environment-behavior relations in such functional systems as health care and transportation; and (3) the effects of planned intervention in the environment on individual and social behavior. These problems are considered with reference to the population in general, as well as special groups such as children, the aged, and the handicapped.

The program trains scientists for problem-oriented research dealing with environment-behavior systems. Instruction emphasizes the application of disciplinary information to problems arising from man's interaction with the physical environment. Doctoral students in the program are expected to acquire skills in a wide range of research and intervention methods and in techniques and theoretical perspectives of man-environment relations, and to develop the competency to generate applied research contributing to a body of knowledge of benefit to the design fields and social science alike.

Providing the appropriate multidisciplinary perspective are faculty with backgrounds in such fields as architecture, city and regional planning, operations research, urban design, social and experimental psychology, organizational behavior, and business administration. In addition to these full-time faculty, the division has available the resources of a group of adjunct faculty in diverse fields related to man-environment relations.

Recent graduates have taken positions with governmental and private research organizations dealing with environmental facilities, services, and problems and with colleges and universities with departments of architecture, planning, psychology, and environmental and urban studies.

Relevant undergraduate preparation may be in the design and planning professions, environmental and urban studies, and other programs in the physical, social, or behavioral sciences appropriate to the study of man-environment systems. Students with a 3.00 junior-senior grade-point average will be considered for admission. Exceptions to the minimum 3.00 average may be made for students with special backgrounds, abilities, and interests.

The program offers an M.S. degree for those entering the program without a master's degree but does not consider it a terminal degree.

Students in the Ph.D. program may elect the dual-title degree program in operations research for the Ph.D. and M.S. degrees (see page p. 239).

The D.Ed. degree program in food service and housing administration equips its students to meet the critical need for educators qualified to staff programs and serve as department heads in hospitality education. The program has been designed to develop professional leadership in the field of hospitality education through a combination of study, research, and teaching experience. The applicant should possess a master's degree in food service and housing administration or a similar academic course of study. The course work leading toward the degree can be arranged to reflect the individual student's interests and prior educational experience. Although the course work can be drawn from appropriate disciplines

throughout the University, the research emphasis focuses predominantly on food service administration and travel and lodging management.

MAN-ENVIRONMENT RELATIONS (M E R)

414. PLANNING COMMUNITY ENVIRONMENTS (3)
435. (Psy. 435) ENVIRONMENTAL STIMULATION AND BEHAVIOR (3)
442. ANALYTIC METHODS IN MAN-ENVIRONMENT RELATIONS II (3)
447. (Soc. 447) ENVIRONMENTAL SOCIOLOGY (3)
452. MAN-ENVIRONMENT RELATIONS LABORATORY II (3)
453. MAN-ENVIRONMENT RELATIONS LABORATORY III (3)
471. HOUSING SPACE RELATED TO LIVING PATTERNS (3)
472. HOUSING PROBLEMS AND POLICIES (3)
480. METHODS FOR THE DESIGN OF ENVIRONMENT-BEHAVIOR SYSTEMS (3)
481. MANAGEMENT METHODS FOR ENVIRONMENT-BEHAVIOR SYSTEMS (3)
482. PLANNING METHODS FOR ENVIRONMENT-BEHAVIOR SYSTEMS (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. NONTHESIS RESEARCH (1-6)
501. PROBLEMS IN MAN-ENVIRONMENT RELATIONS (1-9) Individual directed study, investigation, and practice in selected aspects of man-environment relations.
502. SEMINAR IN MAN-ENVIRONMENT RELATIONS (1-9)
503. RESEARCH METHODS AND EVALUATION IN MAN-ENVIRONMENT RELATIONS (1-9)
505. ENVIRONMENTAL-BEHAVIORAL PROGRAMMING, DESIGN, AND MANAGEMENT (3) Applications of findings in the behavioral sciences to environmental design and management strategies; empirical, theoretical, and methodological issues.
510. PSYCHOLOGICAL FOUNDATIONS OF THE STUDY OF ENVIRONMENT-BEHAVIOR RELATIONS (3) Seminar relating the psychology of perception, cognition, motivation, personality, attitude formation, and psychological stress to aspects of the physical environment.
512. BEHAVIOR ANALYSIS OF ENVIRONMENTAL PROBLEMS (3) Analysis of behaviors contributing to environmental dysfunction. Behavior change strategies are proposed to deal with such problem areas as transportation, pollution, overpopulation.
515. ENVIRONMENTAL SYSTEMS THEORY (3) An in-depth review of those elements of general systems theory relevant to the analysis and organization of man-environment settings.
516. QUANTITATIVE METHODS IN ENVIRONMENTAL MANAGEMENT (3) The use of operations research and systems analysis in the modeling of man-environment systems. Prerequisite: M.E.R. 515.
520. RECENT DEVELOPMENTS IN TEXTILES (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.
523. SOCIETAL DETERMINANTS IN CLOTHING AND TEXTILE DEVELOPMENT (1-6)
534. (Stat. 534) DYNAMIC PROGRAMMING (3) The study of the concepts underlying model-building and optimization of dynamic systems; applications to engineering, economic, and environmental systems. Prerequisites: Stat. 418; I.E. 405 or Q.B.A. 451.
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

402. FOOD SERVICE AND HOUSING LAYOUT AND DESIGN (3)
410. ADVANCED QUANTITY FOOD PRODUCTION (3)
412. FOOD AND BEVERAGE OPERATIONS (3)

- 435. FINANCIAL MANAGEMENT IN HOSPITALITY INDUSTRIES (3)
- 442. HOSPITALITY MERCHANDISING (3)
- 461. PERSONNEL FUNCTIONS IN FOOD SERVICE AND HOUSING ADMINISTRATION (3)
- 470. PROBLEMS IN FOOD SERVICE AND HOUSING ADMINISTRATION (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

MATHEMATICS (MATH)

GERARD LALLEMENT, *In Charge of Graduate Programs in Mathematics*
 229 McAllister Building
 814-865-7527

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Andrews, Armentrout, Axt, C. Ayoub, R. Ayoub, Brownawell, Deutsch, Glasner, Hahn, Herman, Hunter, James, Jech, Kanwal, Krall, Lallement, Maserick, Morris, Olson, Parsons, Rung, Simpson, Stevens, Ware, Waterhouse, Wells, and Yood.

Graduate Faculty: Associate Members J. Anderson, Bressoud, Buhler, Chen, P. Chowla, Formanek, Fulton, Huff, Li, Mansfield, Mitchell, McCammon, Mills, Sibley, Staffeldt, Ware, and Weisfeiler.

Graduate courses in all the principal branches of mathematics are offered regularly each year. The department is prepared to direct research in a variety of fields, including various branches of analysis, algebra, topology, number theory, applied analysis, and mathematical logic and foundations.

To be admitted to the Ph.D., D.Ed., or M.A. program without undergraduate deficiency, an applicant should have completed at least 18 credits in mathematics at the advanced undergraduate level (400 series or their equivalents). The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421), 6 in modern algebra (Math. 480-481), and 3 in topology (Math. 429) or their equivalents. These courses are essential preparation for the graduate program, and if they are taken after admission, a maximum of 6 credits may be counted toward an advanced degree.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

All Ph.D. students must take qualifying examinations in three fields of mathematics. Normally these examinations are taken before the beginning of the third year of graduate study. Recommendations for advancement to Ph.D. candidacy are based on these examinations together with performance in the first two years of study. The comprehensive examination is given after approximately 60 credits are earned and after the student has passed reading examinations in two languages chosen from French, Russian, or German. The Ph.D. student is also expected to enroll in advanced seminars.

Outstanding students who do not continue in the doctoral program may petition the department for further support in order to pursue a second master's degree in another area to which mathematics is applicable.

For the D.Ed. degree, a student must pass qualifying examinations in algebra and analysis and a reading examination in French, German, or Russian before taking the comprehensive examination. In addition to the major thesis, the department requires participation in two terms of research seminar, but no minor thesis is required. The D.Ed. program is intended for college teachers. Three years of experience in professional mathematics teaching on a full-time basis is required for admission. (Graduate teaching assistants are not included in this category.)

For the M.A. degree the department offers two options: (1) the thesis option requires 12 credits of approved 500-series courses in mathematics, 6-9 credits of thesis, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a final oral examination based on the thesis and general course material; and (2) the nonthesis option requires 18 credits of 500-series courses in mathematics with a grade of A or B, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a term paper on an approved topic in mathematics. No final examination is given in this option. A student choosing the program option in operations research must complete a thesis.

To be admitted to the M.Ed. program without undergraduate deficiency, an applicant should have completed at least 15 credits in mathematics at the intermediate level beyond calculus. The M.Ed. program does not require any 500-series courses, but the student is encouraged to select some at this level. Special courses have been instituted for the training of teachers. Among these are Math. 400, 401, 416, 425-426, and 470-471. These are acceptable for the satisfaction of credit requirements only for the M.Ed. degree.

Entering graduate students in mathematics for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. Furthermore, the results of this examination must be received by the Department of Mathematics at least six months prior to the requested date of admission to the Graduate School.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.A. degrees (see p. 239).

A brochure describing more fully the graduate program in mathematics is available from the Department of Mathematics.

MATHEMATICS (MATH)

- 400. PROBABILITY FOR TEACHERS (3)
- 401. GEOMETRY FOR TEACHERS (3 EACH)
- 404. THEORY OF NUMBERS (3)
- 406. TOPICS IN THEORY OF NUMBERS (3)
- 409. (Stat. 409) INTRODUCTION TO PROBABILITY THEORY (3)
- 410. (Stat. 410) MATHEMATICAL STATISTICS I (3)
- 411. FINITE DIFFERENCES (3)
- 412. (Stat. 412) MATHEMATICAL STATISTICS II (3)
- 416. MATHEMATICAL LOGIC FOR TEACHERS (3)
- 417. (A.M. 417) TENSOR ANALYSIS (3)
- 418. (A.M. 418, Stat. 418) DISCRETE PROBABILITY THEORY (3)
- 419. (A.M. 419, Phys. 419) THEORETICAL MECHANICS (3)
- 420. INTRODUCTION TO ANALYSIS I (3)
- 421. INTRODUCTION TO ANALYSIS II (3)
- 422. ALGEBRAIC GEOMETRY (3)
- 423. METRIC DIFFERENTIAL GEOMETRY (3)
- 425-426. ANALYSIS FOR TEACHERS (3 each)
- 427. (Stat. 427) DISCRETE STOCHASTIC MODELS (3)
- 428. (Phil. 428) LOGICAL THEORY (3)
- 429. GENERAL TOPOLOGY (3)
- 430. ELEMENTARY ALGEBRAIC TOPOLOGY (3)
- 431. (A.M. 431) ORDINARY DIFFERENTIAL EQUATIONS (3)
- 432. (A.M. 432) FOURIER SERIES AND PARTIAL DIFFERENTIAL EQUATIONS (3)
- 433. (A.M. 433) OPERATIONAL MATHEMATICS (3)
- 435. AXIOMATIC SET THEORY (3)
- 441. (A.M. 441) MATRIX ALGEBRA (3)
- 451. (A.M. 451) ADVANCED CALCULUS FOR ENGINEERS I: REAL VARIABLES (3)
- 452. (A.M. 452) ADVANCED CALCULUS FOR ENGINEERS II: COMPLEX ANALYSIS (3)
- 453. (Cmp.Sc. 453) NUMERICAL COMPUTATIONS (3)
- 454. (Cmp.Sc. 454) MATRIX COMPUTATIONS (3)
- 456. COMPUTABILITY AND UNSOLVABILITY (3)
- 461. (A.M. 461, Phys. 461) THEORETICAL MECHANICS (3)
- 465. CLASSICAL ANALYSIS I (3)
- 466. CLASSICAL ANALYSIS II (3)
- 470-471. ALGEBRA FOR TEACHERS (3 each)
- 472. FOUNDATIONS OF GEOMETRY (3)
- 480. BASIC ABSTRACT ALGEBRA (3)
- 481. LINEAR ALGEBRA (3)
- 484. LINEAR PROGRAMS AND RELATED PROBLEMS (3)
- 485. GRAPH THEORY (3)

- 489. MATHEMATICS SEMINAR (1-6)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501-502. THEORY OF FUNCTIONS OF A REAL VARIABLE (3 each) Sets, metric spaces, measure and integration, L_p spaces and other function spaces, differentiation. Prerequisite: Math. 421.

504. (A.M. 504) OPTIMIZATION THEORY (3) Least squares problems, min-max game theory, global theory of constrained optimization, iterative methods of optimization. Prerequisite: Math. 420.

505. (A.M. 505) INTEGRAL EQUATIONS (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. (A.M.) 431 or 432 or Math. 420.

506. (A.M. 506) DISTRIBUTIONS AND GENERALIZED FUNCTIONS (3) Schwartz-Sobolev theory of distributions, tempered distributions, Fourier transforms, fundamental solutions of ordinary and partial differential equations; applications. Prerequisite: Math. (A.M.) 431 or 432 or Math. 420.

507. (A.M. 507) CALCULUS OF VARIATIONS AND OPTIMAL CONTROL (3) Classical and modern theory of the calculus of variations; problems in optimal control. Prerequisite: Math. (A.M.) 431 or 432 or Math. 420.

508-509. COMPLEX ANALYSIS (3 each) Analytic and meromorphic functions; Riemann's mapping theorem. Prerequisite: Math. 421.

511. LINEAR ALGEBRA (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisite: Math. 481 or 537.

515. (A.M. 515) PARTIAL DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: Math. (A.M.) 431 or 432.

516. (A.M. 516) ADVANCED PARTIAL DIFFERENTIAL EQUATIONS (3) Elliptic operators, fundamental solutions, weak and strong derivatives, Sobolev inequalities, Dirichlet problem, equations of evolution, semi-groups. Prerequisites: Math. (A.M.) 515.

517-518. (Stat. 517-518) PROBABILITY THEORY (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

520. PROJECTIVE GEOMETRY (3) General study of the subject from the synthetic and analytic standpoint. Prerequisites: Math. 472, 480.

521. ANALYTIC NUMBER THEORY I (3) Improvements of the prime number theorem, L -functions and class numbers, asymptotic and arithmetic properties of coefficients of modular forms. Prerequisites: Math. 508, 594.

522. ANALYTIC NUMBER THEORY II (3) Distribution of primes, analytic number theory in algebraic number fields, transcendental numbers, advanced theory of partitions. Prerequisite: Math. 521.

523. DIFFERENTIAL GEOMETRY (3) Manifolds-differentiable structures, tangent spaces, connections, structural equations, Riemannian geometry. Prerequisite: Math. 429.

524. ADVANCED COMPLEX ANALYSIS (3) Topics include boundary behavior of analytic functions, bounded analytic functions, conformal mapping, theory of Riemann surfaces. Prerequisite: Math. 509.

525. THEORY OF FUNCTIONS OF SEVERAL COMPLEX VARIABLES (3-6) Topics include fundamental properties of holomorphic functions, complex analytic manifolds, integral representations, Cousin problems. Prerequisite: Math. 509.

526. THEORY OF SHEAVES (3) Presheaves over topological spaces; defining sheaves two ways; Čech cohomology of presheaves; cohomology of sheaves; flasks; Lubkin's punctual cochains. Prerequisites: Math. 429; Math. 480 or 535.

527. ALGEBRAIC GEOMETRY (3) Preschemes and proschemes; products; projective finite and affine

presentation maps; projective quasicoherent sheaves; cohomology of quasicoherent sheaves over affine schemes. Prerequisite: Math. 526.

528. **UNIFORM SPACES AND FUNCTION SPACES (3)** Uniform spaces, completion, compactifications, function spaces, metrization. Prerequisite: Math. 429.

529-530-531. **TOPOLOGY (3 each)** Topological, product, compact, metric, and connected spaces; continuous functions; separation axioms, countability conditions, combinatory topology.

532. **SET THEORY (3)** Axiomatic set theory, cardinal arithmetic, infinitary combinatorics. Constructible universe, forcing, and generic models. Consistency and independence of the continuum hypothesis. Prerequisite: Math. 554 (Phil. 554); Math. 556.

533. **ADVANCED SET THEORY (3)** The constructible universe, forcing, trees, infinitary combinatorics, large cardinals; applications to topology, measure theory, and projective set theory. Prerequisite: Math. 532.

535-536-537. **ALGEBRA (3 each)** Basic theory of semigroups and groups, rings and modules, fields, lattices.

538. **COMMUTATIVE ALGEBRA (3)** Topics selected from noetherian rings and modules, primary decompositions, Dedekind domains and ideal theory, other special types of commutative rings or fields. Prerequisite: Math. 536.

539. **RINGS (3)** Selected topics from the theory of rings. Prerequisite: Math. 536.

542. (Stat. 542) **STATISTICAL DISTRIBUTION THEORY IN SCIENTIFIC WORK: I. DISCRETE MODELS (3)** Statistical distributions arising in scientific modeling and statistical inference; structures, interrelations, characterizations, and simulation with practical examples. Prerequisite: Math. (Stat.) 410; knowledge of matrix algebra.

543. (Stat. 543) **STATISTICAL DISTRIBUTION THEORY IN SCIENTIFIC WORK: II. CONTINUOUS MODELS (3)** Statistical distributions arising in scientific modeling and statistical inference; structures, interrelations, characterizations, and simulation with practical examples. Prerequisite: Math. (Stat.) 542.

544. **APPLIED ALGEBRA I (3)** Basic algorithms of algebra, application to number theory, group theory, field theory, linear algebra, and combinatorics. Prerequisites: Math. 480, 481, and ability to use a computer.

545. **APPLIED ALGEBRA II (3)** Analysis and implementation of various algorithms used in current mathematical research. Prerequisite: Math. 544.

547-548-549. **LIE THEORY (2 each)** Topics selected from theory of topological semigroups, topological groups, lie groups, transformation groups. Prerequisite: Math. 531.

551. (Cmp.Sc. 551) **NUMERICAL ALGEBRA (3)** Zeros of polynomials; iterative solution of linear and nonlinear systems; sparse matrix techniques; eigenvalues and eigenvectors. Prerequisite: Cmp.Sc. 454 or Math. 441.

552. (Cmp.Sc. 552) **INTRODUCTION TO APPROXIMATION THEORY (3)** Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420 and 3 credits in computer science.

553. (Cmp.Sc. 553) **NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS (3)** Methods for initial value and boundary value problems. Stability and convergence analysis, automatic error control, and stiff systems. Prerequisites: Cmp.Sc. 453, Math. 431.

554. (Phil. 554) **LOGIC AND METAMATHEMATICS (3)** Completeness, Lowenheim-Skolem and compactness theorems. First-order arithmetic, recursiveness and the incompleteness and consistency of arithmetic. Prerequisite: Math. 428.

555. **ADVANCED RECURSION THEORY (3)** Recursively enumerable sets, degrees of unsolvability, admissible ordinals, inductive definitions, projective hierarchy, fine structure of the constructible hierarchy. Prerequisite: Cmp.Sc. 559 or Math. 556.

556. RECURSION THEORY (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions; recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Math. 554 (Phil. 554).
557. MODEL THEORY (3) Countable models, saturated models, categorical theories and related topics. Prerequisites: Math. 532, 556.
- 560-561. (A.M. 560-561) ORDINARY DIFFERENTIAL EQUATIONS (3 each) Linear spaces and operators, existence and uniqueness of solutions, linear systems, Green's functions, eigenvalue problems—including Fourier series. Prerequisite: Math. 72 or 250 or 383 or Math. (A.M.) 431.
562. THEORY OF SPECIAL FUNCTIONS (3) Topics include asymptotic expansions; Riemann-Papperitz and Trusdell's F equations; orthogonal polynomials; generating, beta, zeta, hypergeometric, Bessel, Legendre, elliptic functions. Prerequisites: Math. 72 or 250 or 383 and either Math. 420 and 452, or Math. 508.
563. APPROXIMATION THEORY (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds; degree of approximation; approximation of linear functionals. Prerequisites: Math. 453, 501.
564. (Cmp.Sc. 564) NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS (3) Methods of parabolic, hyperbolic, and elliptic partial differential equations; finite difference and variational methods; splines, finite elements. Prerequisites: Cmp.Sc. 453, 454; A.M. 451 or Math. 405.
565. FUNCTIONAL ANALYSIS (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 502.
566. ALGEBRAIC NUMBER THEORY I (3) Dedekind rings; cyclotomic and Kummer extensions; valuations; ramification, decomposition, inertial groups; Galois extensions; locally compact groups of number theory. Prerequisites: Math. 537, 594.
567. ALGEBRAIC NUMBER THEORY II (3) Local and global class field theory; integral quadratic forms; algebraic and arithmetic groups; algebraic function of one variable. Prerequisite: Math. 566.
568. ADVANCED ALGEBRA I (3) Noetherian and Artinian modules and rings, simple and semi-simple modules and rings, radicals. Prerequisite: Math. 537.
569. ADVANCED ALGEBRA II (3) Multilinear algebra, commutative algebra, homological algebra. Prerequisite: Math. 568.
570. SPECIAL TOPICS IN GEOMETRY (3-12)
571. SPECIAL TOPICS IN ANALYSIS (3-12)
572. SPECIAL TOPICS IN ALGEBRA (3-12)
573. SPECIAL TOPICS IN APPLIED MATHEMATICS (3-12)
574. SPECIAL TOPICS IN FOUNDATIONS OF MATHEMATICS (3-12)
- 575-576. MATHEMATICS SEMINAR (1-6 each) Selected topics from recent mathematical developments.
578. SPECIAL TOPICS IN TOPOLOGY (3-12)
579. (Cmp.Sc. 579) SPECIAL TOPICS IN NUMERICAL ANALYSIS (2-12)
580. SPECIAL TOPICS IN NUMBER THEORY (2-12)
- 581-582. GROUP THEORY I, II (3 each) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 535.
583. HOMOLOGICAL ALGEBRA (3) Modules, diagrams, functors, homology of complexes, resolutions, cohomology of groups, tensor and torsion products. Prerequisite: Math. 536.
- 584-585-586. ALGEBRAIC TOPOLOGY (2 each) Development of singular and Čech homology and cohomology theories; homotopy and cohomotopy theories. Prerequisite: Math. 531.

590. COLLOQUIUM (1-3)

592-593-594. NUMBER THEORY (3 each) Congruences, quadratic residues, arithmetical functions, Dirichlet's theorem, prime number theorem, classical multiplicative ideal theory, partitions, valuations and p-adic numbers, divisors. Prerequisite: Math. 480. Prerequisite or concurrent: Math. 508.

596. INDIVIDUAL STUDIES (1-6)**597. SPECIAL TOPICS (1-6)****602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2)**

NOTE: *Courses in Applied Mathematics, Computer Science, and Statistics are listed separately.*

MATHEMATICS (MATH)

HELMUT E. WEBER, *In Charge of the Graduate Program in Mathematics*
Radnor Center, 259 Radnor-Chester Road, Radnor, PA 19087
215-293-9860

Degree Conferred: M.Ed.

Graduate Faculty: Associate Members Callahan, Duncan, and Llorens.

The program is offered specifically to permit teachers in the area to pursue advanced studies through evening classes while employed in teaching. Courses offered for the program are established and controlled by the resident departments at the University Park Campus.

Credit requirements may be satisfied by completing a minimum of 18 credits in approved mathematics courses, a minimum of 6 credits in approved mathematics and science courses, and a minimum of 6 credits in approved education courses. In addition, a term paper is required. All requirements must be met within six years or seven consecutive summers.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. An applicant must have a bachelor's degree and have completed 27 credits in mathematics including at least 15 credits at the intermediate level beyond calculus. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details concerning this program may be obtained by writing directly to the Radnor Center for Graduate Studies.

MECHANICAL ENGINEERING (M E)

DONALD R. OLSON, *Head of the Department*
207 Mechanical Engineering Building
814-865-2519

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Brickman, Cunningham, Faeth, Heinsohn, Henderson, Henry, Kuo, Lestz, Olson, Park, Reethof, Schmidt, Shearer, Wambold, Weber, and Wolgemuth.

Graduate Faculty: Associate Members Hayhoe, Huber, Hughes, Merkle, Midha, Parke, Smith, Turns, and Webb.

Graduate programs and research facilities are available in thermodynamics and combustion, heat transfer, fluid mechanics, dynamic system analysis, mechanical design, biomedical engineering, and energy systems. Air pollution control, automotive safety, designing for noise control and for reliability also provide many research and design opportunities.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an in-depth study of one foreign language (6 credits), by taking two or more courses (minimum of 6 credits) of a nontechnical nature in a single area of study appropriate and related to the student's career orientation, or by taking an advanced technical writing course (Engl. 418 — 4 credits) and presenting a formal proposal for thesis research (M.E. 580 — 2 credits) to the doctoral committee.

A student working toward an M.S. degree may choose one of the following options: (1) a minimum of 24 course credits plus 6 thesis credits (M.E. 600) culminating in the submission of a thesis to the Graduate School, (2) a minimum of 30 course credits plus a technical report, or (3) a minimum of 30 course credits plus submission of a Ph.D. thesis research proposal, provided the student has passed the candidacy examination.

The entering student must hold a bachelor's degree in engineering or physical science. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MECHANICAL ENGINEERING (M E)

- 400. HONORS THESIS (1-3)
- 403. ROCKET PROPULSION (3)
- 405. AIR POLLUTION CONTROL SYSTEMS (3)
- 409. GAS TURBINES (3)
- 410. POWER PLANTS (3)
- 411. REFRIGERATION AND AIR CONDITIONING (3)
- 412. HEAT TRANSFER (3)
- 413. INTERNAL COMBUSTION ENGINES (3)
- 414. ENGINEERING ANALYSIS OF THERMAL SYSTEMS (3)
- 415. ENGINEERING ANALYSIS FOR MECHANICAL DESIGN (3)
- 417. THEORY OF ENGINEERING INSTRUMENTS (3)
- 418. PRINCIPLES OF TURBOMACHINERY (3)
- 420. HEAT-EXCHANGER DESIGN (3)
- 421. (Aersp. 421) INTERMEDIATE VISCOUS FLOW (3)
- 450. DESIGN OF MACHINE TOOLS (3)
- 451. ADVANCED MACHINE DESIGN PROBLEMS (3)
- 452. DESIGN ANALYSIS (3)
- 454. ADVANCED MACHINE DYNAMICS (3)
- 455. AUTOMATIC CONTROL SYSTEMS (3)
- 458. NOISE CONTROL IN MACHINERY (3)
- 460. RELIABILITY CONCEPTS IN DESIGN (3)
- 470. FUNDAMENTALS OF AIR POLLUTION (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 503. THERMODYNAMIC PROCESS ANALYSIS (3) Development of equations governing separate processes in complete machines to give basic system parameters and characteristics; transient processes; irreversible effects.
- 504. ADVANCED ENGINEERING THERMODYNAMICS (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject.
- 505. DESIGN OF AIR POLLUTION CONTROL SYSTEMS (3) Advanced principles of design drawn from professional literature, including mechanical collectors, electrostatic precipitators, filters, scrubbers, and industrial ventilation systems. Prerequisite: M.E. 405.
- 506. SELECTED TOPICS IN MECHANICAL ENGINEERING (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.

512. **HEAT TRANSFER — CONDUCTION (3)** One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions.
513. **HEAT TRANSFER — CONVECTION (3)** Laminar and turbulent flow heat transfer in natural and forced convection systems.
514. **HEAT TRANSFER — RADIATION (3)** Thermal radiation fundamentals; specular and diffuse systems; differential and integral methods; numerical techniques; industrial applications.
515. **TWO-PHASE HEAT TRANSFER (3)** Heat transfer processes involving evaporation, boiling, and condensation.
516. **COMBUSTION IN PROPULSION SYSTEMS (3)** Theoretical formulations and methods of solution of engineering problems and physical processes in chemical propulsion systems.
519. **COMPRESSIBLE FLUID FLOW (2-4)** Two-dimensional subsonic flow; similarity rules; theory of characteristics; supersonic and hypersonic flows; nonsteady flow; oblique shock waves.
521. **ELECTROMAGNETIC AND THERMODYNAMIC FLOW SYSTEMS (3)** Thermodynamic equations for flow of reacting and nonreacting fluids in electromagnetic fields; applications to engineering problems.
522. **BOUNDARY LAYER AND SEPARATED FLOWS (3)** Behavior of viscous fluids, with emphasis on boundary layer and separation effects in internal flow.
540. **NUMERICAL SOLUTIONS APPLIED TO HEAT TRANSFER AND FLUID MECHANICS PROBLEMS (3)** Application of finite difference methods to the study of potential and viscous flows and conduction and convection heat transfer.
552. **ADVANCED DYNAMICS OF MACHINES (3-6)** Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.
555. **AUTOMATIC CONTROL SYSTEMS (3)** Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.
557. **MECHANISM SYNTHESIS (3)** Geometrical and algebraic methods for synthesizing planar and spatial mechanisms, dynamics of spatial mechanism.
558. **FLUID CONTROL SYSTEMS (2)** Modeling fluid system dynamic performance, experimental determination of the actual behavior, and comparison of predicted behavior with actual behavior. Prerequisite: M.E. 455.
562. **SIMULATION OF MECHANICAL SYSTEMS (3)** Introduces computational fundamentals, including digital logic; programming language, basic numerical analysis and data processing, as applied to mechanical simulation techniques. Prerequisites: M.E. 54, 66.
571. **AIR POLLUTION SEMINARS (1-2)** Weekly seminars featuring the contributions of many different disciplines to the solution of air pollution and other environmental problems.
580. **INVESTIGATION PROJECTS (1-6)** Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

METALLURGY (METAL)

HOWARD W. PICKERING, *In Charge of Graduate Programs in Metallurgy*
209 Steidle Building
814-865-5446

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bitler, Hoke, Muan, Pickering, Ryba, Simkovich, and Thrower.

Graduate Faculty: Associate Members Osseo-Asare and Small.

This program is one of the options in which a graduate student in the Department of Materials Science and Engineering can receive an advanced degree. A student may specialize, through both course work and research, in the science and engineering aspects of chemical, physical, or mechanical metallurgy.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language together with courses from other designated areas.

Suitable preparation for graduate study in this program may be found in one of the material sciences such as ceramic science, fuel science, metallurgy, or solid state science; in engineering fields such as chemical or mechanical engineering; in basic physical sciences such as chemistry or physics; or in earth sciences such as geochemistry and mineralogy. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METALLURGY (METAL)

401. METALLURGICAL PROCESSES AND KINETICS (3)
402. CORROSION ENGINEERING (3)
403. PHYSICAL METALLURGY LABORATORY (1)
404. DESIGN OF PYROMETALLURGICAL SYSTEMS (3)
405. PHYSICAL METALLURGY (3)
406. ALLOY SYSTEMS (3)
407. SOLIDIFICATION PROCESSING (3)
408. DEFORMATIONAL PROCESSING (3)
410. METALLURGICAL INVESTIGATIONS AND DESIGN (1-6)
412. SOLID STATE METALLURGY (3)
414. EXTRACTIVE METALLURGY LABORATORY (1)
416. HYDROMETALLURGY LABORATORY (1)
426. (Mn.Pr. 426) HYDROMETALLURGY (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

501. METALLURGICAL PROBLEMS (1-6 per term) Independent study of special problems in metallurgy.
505. OXIDATION OF METALS (3) The course will cover high-temperature oxidation of metals and alloys including Wagner's theories of internal oxidation. Prerequisite: Chem. 451. *Simkovich*
507. (Mn.Pr. 507) HYDROMETALLURGICAL PROCESSING (3) Fundamental physico-chemical factors underlying the aqueous extraction and recovery of metals and non-metals from ores, minerals, and scrap metal. Prerequisite: Metal (Mn.Pr.) 426. *Simkovich*
508. KINETICS OF PHASE TRANSFORMATIONS (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates. *Bitler*
509. INTRODUCTORY THEORETICAL PHYSICAL METALLURGY (3) Quantum mechanics and its application to solid-state theory; introduction of Schroedinger's equation, its solutions, free-electron model, band model. *Bitler*
510. MAGNETIC AND TRANSPORT PROPERTIES OF MATERIALS (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: Metal. 509. *Bitler*
513. ADVANCED CHEMICAL METALLURGY I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites: Chem. 452, Metal. 301, 402, 404. *Simkovich*
514. DISLOCATION THEORY (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Bitler*

515. CORROSION OF METALS (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments. *Pickering*

516. FLOW AND FRACTURE OF SOLIDS (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisite: Metal. 514.

518. HETEROGENEOUS EQUILIBRIA AT HIGH TEMPERATURES (2-3) Treatment of high-temperature equilibria in metal and oxide systems involving crystalline, liquid, and gas phases. Prerequisite: Metal. 513. *Muan*

519. ADVANCED CHEMICAL METALLURGY II (3) Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: Metal. 513. *Small*

520. FOUNDRY METALLURGY (3) Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisite: Metal. 513.

522. SOLID-PHASE REACTIONS IN METALS (3) Mechanisms and rate-determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisite: Metal. 508. *Bitler*

535. (E.Mch. 535) CRYSTAL DEFECTS AND MECHANICAL RESPONSE (3) Mechanical responses of crystalline solids containing point, line, and interfacial defects; elastic and plastic responses. Prerequisite: Metal. 514 or E.Mch. 414. *Queeney*

NOTE: Courses in introductory thermodynamics and kinetics of metals, and the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Materials Science.

METEOROLOGY (METEO)

ALFRED K. BLACKADAR, *Head of the Department*
503 Deike Building
814-865-0478

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthes, Blackadar, Cahir, R. de Pena, Dutton, Fraser, Hosler, Panofsky, and Thomson.

Graduate Faculty: Associate Members Albrecht, Clark, Olivero, and J. Pena.

Candidates may specialize in the study of problems in either theoretical or applied meteorology including such areas as cloud physics, various phases of dynamic meteorology and geophysical fluid dynamics including turbulence and atmospheric circulation, numerical modeling, macro- and microclimatology, synoptic meteorology, or meteorological instrumentation. The department also encourages interdisciplinary studies in such fields as agricultural meteorology, biometeorology, water resources, air pollution, and fluid mechanics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of German or Russian. The thesis or paper option is available for the M.S. degree.

Requirements for admission include mathematics through differential equations and one year of college physics. Undergraduate study of meteorology is not required for admission. Special programs are available to encourage the graduate study of meteorology by all students with strong backgrounds in mathematics, physics, or engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METEOROLOGY (METEO)

400. METEOROLOGY FOR TEACHERS (3)
 401. PHYSICAL CLIMATOLOGY FOR TEACHERS (3)
 404. MOTIONS OF THE ATMOSPHERE AND OCEANS (3)
 407. ELEMENTS OF PHYSICAL OCEANOGRAPHY (3)
 411. INTRODUCTORY PHYSICAL METEOROLOGY (3)
 418. INTRODUCTORY PHYSICS OF THE UPPER ATMOSPHERE (3)
 420. TROPICAL METEOROLOGY (3)
 430. INTRODUCTION TO SYNOPTIC METEOROLOGY LABORATORY (3)
 431. SYNOPTIC METEOROLOGY LABORATORY I (3)
 432. SYNOPTIC METEOROLOGY LABORATORY II (2-10)
 433. ADVANCED SYNOPTIC ANALYTICAL TECHNIQUES (3)
 434. APPLICATION OF METEOROLOGICAL SATELLITE DATA TO ANALYSIS AND FORECASTING (3)
 442. OBSERVING METEOROLOGICAL PHENOMENA (3)
 443. RADIATIVE TRANSFER (3)
 446. (Geosc. 402) NATURAL DISASTERS SEMINAR (2)
 450. APPLICATIONS OF STATISTICS TO METEOROLOGY (3)
 451. DYNAMIC METEOROLOGY I (3)
 452. DYNAMIC METEOROLOGY II (3)
 453. DYNAMIC METEOROLOGY III (3)
 461. THEORY OF METEOROLOGICAL INSTRUMENTS (3)
 472. PHYSICAL AND DYNAMIC CLIMATOLOGY (3)
 473. INTRODUCTION TO MICROMETEOROLOGY (3)
 475. ATMOSPHERIC CHEMISTRY AND PHYSICS OF CLOUDS (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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502. SELECTED TOPICS OF ADVANCED METEOROLOGY (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.
 503. ATMOSPHERIC TURBULENCE (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.
 505. BIOCLIMATOLOGY (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.
 506. ADVANCED METEOROLOGICAL ANALYSIS (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.
 507. DYNAMIC OCEANOGRAPHY (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.
 508. PHYSICS OF THE UPPER ATMOSPHERE (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.
 509. THEORETICAL CLIMATOLOGY (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.
 510. CLOUD PHYSICS (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.
 520. INDIRECT ATMOSPHERIC PROBING (3) Analysis and description of measurements made with radar and bistatic radio, optical and acoustic systems used for indirect atmospheric sounding. Prerequisite: Meteo. 443.
 550. ATMOSPHERIC MOTIONS (3) Fundamental properties and conservation requirements of the hydrodynamic equations; elements of advanced dynamic meteorology and applications to atmospheric dynamics. Prerequisite or concurrent: A.M. 451.
 551. ATMOSPHERIC WAVE MOTION (2-3) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 550.

552. NUMERICAL WEATHER PREDICTION (2-3) Finite difference and spectral methods, barotropic and baroclinic models, filtered and primitive equation models, synoptic-scale and mesoscale models. Prerequisite: Meteo. 550.

553. ENERGETICS OF ATMOSPHERIC MOTION (2-3) Theoretical investigation of the conversions of energy in the atmosphere; maintenance of the general circulation and global thermodynamics. Prerequisite: Meteo. 550.

555. ATMOSPHERIC DIFFUSION (2-3) Dispersion of atmospheric contaminants; experiments, theory and practical implications for air pollution problems. Prerequisite: 3 credits of statistics.

561. CHEMISTRY OF THE ATMOSPHERE (2) Fundamental knowledge of chemical characteristics of atmospheric components and transformations, in connection with cloud microphysics, circulation, and air pollution. Prerequisite: 3 credits in chemistry.

597. SPECIAL TOPICS (1-6)

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Materials Science.*

MICROBIOLOGY (MICRB)

EDWIN V. GAFFNEY, *In Charge of Graduate Programs in Microbiology*
S-306 Frear Building
814-865-9472

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Casida, Ceglowski, Docherty, Gaffney, Lindstrom, Ludwig, Pootjes, Tershak, Zarkower, and Zimmerman.

Graduate Faculty: Associate Members McDonel, Porter, Schlegel, Stevens, and Yasbin.

Opportunities for graduate study are available in microbiology, immunology, virology, and cell biology. Among current areas of research are included such topics as bacterial ecology, genetics, and physiology; food and industrial microbiology; photosynthesis of procaryotes; chemical and pathogenic properties of both bacterial and animal viruses; viral and tumor immunology; and mammary carcinogenesis. There is opportunity for cooperative research with other departments.

The communication and foreign language requirement for the Ph.D. may be satisfied by intermediate knowledge of one foreign language (French, German, or Russian).

Prerequisites for admission are 16 credits in inorganic and organic chemistry, 6 in physics, 4 in microbiology, and mathematics through calculus. Admission may be granted with deficiencies up to 8 credits, to be made up while pursuing graduate work. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. A satisfactory score on the Graduate Record Examination is required for admission.

MICROBIOLOGY (MICRB)

400. INTRODUCTORY ENVIRONMENTAL MICROBIOLOGY (2)

401. ADVANCED BACTERIOLOGY (2)

408. LABORATORY INSTRUCTIONAL PRACTICE (1-2)

410. IMMUNOLOGY AND SEROLOGY (2)

411. SURVEY OF MICROBIOLOGY (1 per term)

412. MEDICAL MICROBIOLOGY (2)

413. MICROBIAL SOIL ECOLOGY (2)

414. FOOD MICROBIOLOGY (2-4)

415. INTRODUCTION TO ANIMAL VIRUSES (2)

- 416. INDUSTRIAL MICROBIOLOGY (2)
- 417. EPIDEMIOLOGY (2)
- 418. BACTERIAL VIRUSES (2)
- 421. LABORATORY OF GENERAL AND APPLIED MICROBIOLOGY (2)
- 422. PRACTICAL MEDICAL MICROBIOLOGY (2)
- 474. ADVANCED CELL BIOLOGY (2)
- 476. THE PHOTOSYNTHETIC PROCESS (3)
- 478. THE BIOLOGY OF CANCER CELLS (2)
- 496. INDEPENDENT STUDIES (1-12)

- 507. SEMINAR (1 per term) Reports on current fields of research.
- 508. BACTERIAL PHYSIOLOGY (2-4) Contributions of environment, finestructure, and metabolism to the functioning cell. Prerequisite: 6 credits of biochemistry.
- 510. ADVANCED IMMUNOLOGY (2) Discussions of the modern concepts in immunology. Emphasis on areas of current interest. Prerequisites: Micrb. 410, 6 credits in biochemistry.
- 512. MICROBIOLOGICAL METHODS (1-6) Practice in special laboratory techniques of modern microbiology.
- 516. BACTERIAL GENETICS (2-4) Mechanisms of variation in microorganisms including mutation, adaptation, sexual recombination, transduction, and transforming factors. Prerequisites: 3 credits each in microbiology and genetics.
- 520. BIOCHEMICAL VIROLOGY (2) Role of enzymes and nucleic acids in virus synthesis. Regulation of virus reproduction in animal and bacterial cells. Prerequisite: 6 credits of biochemistry.
- 529. (C.E. 579) AQUATIC MICROBIOLOGY (3) Ecology and physiology of microorganisms of inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

MICROBIOLOGY (MICRO)

FRED RAPP, *Chairman of the Department*
 The Milton S. Hershey Medical Center
 Hershey, PA 17033
 717-534-8253

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bartlett, Geder, Hyman, Kreider, Rapp, Taylor, M. Tevethia, and S. Tevethia.

Graduate Faculty: Associate Members Howett, Isom, Lipton, Marquez, Sattler, and Tenser.

This program is oriented toward the study of viruses and includes programs in viral oncology, viral genetics, tumor immunology, virus gene expression, and virus latency. The molecular biology of eukaryotic systems is an additional focus.

The communication and foreign language requirement may be satisfied by demonstrating competence in a foreign language, such as French, German, or Russian. Alternatively, courses which enhance communication skills can be substituted for the foreign language requirement.

Qualified students with undergraduate preparation in either the biological, biochemical, or physical sciences may apply. An adequate background in biology, chemistry, and mathematics and an overall grade-point average of 3.00 or better are required.

The best-qualified applicants will be accepted on a space-available basis. Formal applications should contain two letters of recommendation and a brief personal essay summarizing the background and professional goals of the applicant. Graduate Record Examination scores are required.

This program is offered only at The Milton S. Hershey Medical Center.

MICROBIOLOGY (MICRB)

551. **MEDICAL MICROBIOLOGY (3)** Principles of medical microbiology: bacterial structure and function, host-parasite relationships, and bacteria, fungi, and viruses causing human disease.
552. **MEDICAL MICROBIOLOGY LABORATORY (1)** Laboratory exercises to augment Micrb. 551. Laboratory tests used to characterize microorganisms and to aid in diagnosis of disease. Concurrent: Micrb. 551.
553. **SCIENCE OF VIROLOGY (3)** Replication of viruses and effect on host, including transfer of genetic information, immunology, and oncogenic properties of viruses.
554. **PRINCIPLES OF IMMUNOLOGY (2)** Study of immune response. Nature of antigens, structure, function of antibodies, hypersensitivity, transplantation and tumor immunology, autoimmunity, and immunosuppression.
555. **MICROBIAL PHYSIOLOGY AND METABOLISM (3)** Physiology and comparative biochemistry of microorganisms, especially human pathogens. Regulatory mechanisms, energy metabolism, and other topics essential for cell replication.
556. **MOLECULAR GENETICS (3)** Structure, synthesis, and function of DNA, RNA, and proteins. Emphasis on gene structure and function in the eucaryotic cell.
557. **ELECTRON MICROSCOPY (3)** The application of electron microscopy to microbiology, including specimen preparation, use of the electron microscope, and photography. Prerequisites: admission to the medical or graduate program and permission of instructor.
558. **MEDICAL PARASITOLOGY (2)** Basic information on protozoa, helminths, arthropods, and mollusks involved in the causation of human diseases.
559. **EPIDEMIOLOGY (2)** Provides information on epidemiology—the study of factors that affect occurrence and course of disease in a population.
572. **LITERATURE REPORTS (1 per term)** Weekly analysis of current literature in microbiology.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

MINERAL ECONOMICS (MN EC)

RICHARD L. GORDON, *In Charge of Graduate Programs in Mineral Economics*
 221 Walker Building
 814-865-2549

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Gordon, Schenck, Tilton, and Vogely.

The program in mineral economics prepares students for careers in mineral industries management, administration, or economic analysis and planning. Students may specialize in such areas as commodity analysis (energy, metals, or nonmetals); resource economics (mineral policy or area studies); industrial economics (administration, market research, or financial matters); geostatistical and economic analysis of exploration and exploitation problems; or operations research and statistics (resource allocation, forecasting, or decision making).

Two related, but distinctly different, general programs for obtaining the M.S. and Ph.D. degrees are available, the one chosen depending on the education and practical experience of the candidate. One program is for students whose background is in the mineral industries and who wish to combine their scientific training with an understanding in depth of the methods by which economics can aid in solving problems in mineral industries exploration, exploitation, and processing. Requirements for admission to this program are 24 credits in chemistry, physics, mathematics, or statistics; 12 in the earth sciences;

9 in economics, mineral economics, commerce, business administration, or industrial management; and 6 in engineering subjects.

The second program is for students whose background is in economics and whose training and experience have given them an interest in applying their economic skills to the solution of mineral industries problems. Requirements for admission to this program are 12 credits in economics, mineral economics, and business administration; 6 in geological sciences; and 9 in mathematics and statistics.

The differences between the programs followed by these two groups of students will affect many aspects of their graduate programs — thesis work, required mineral economics courses, and elective selection. In all cases, the choices among courses and the emphasis within courses taken would be determined by the background of the student. The mineral-industries-based program places equal emphasis on the technical and economic aspects of mineral economics, and the economics-based program places more emphasis on the economic than on the technical features of the problems considered.

In addition to the normal degree requirements of the Graduate School, candidates for the M.S. degree must write a thesis and defend it orally. Doctoral candidates in the mineral-industries-based program must complete at least 15 credits in economics (including courses used for admission). M.S. students in both programs are also required to take 9-12 credits in statistics and computer science either before admission or as courses taken in addition to the minimum required for the M.S. degree. Doctoral candidates in the economics-based program must complete at least 12 credits in the earth sciences or mineral engineering. The candidacy examination for the doctorate is oral, and the oral examination for the M.S. degree at The Pennsylvania State University may be used as the candidacy examination for the doctorate. If this is done, the M.S. examination will be more detailed and broader in scope than it would be for the M.S. alone. The comprehensive examination for the doctorate includes written examinations in the major program and minor fields in addition to the oral examination required by the Graduate School. The communication requirement is satisfied by departmentally approved courses in mathematical statistics and mathematics. There is no foreign language requirement.

Students with deficiencies of 9 credits or fewer in either program may be admitted as degree candidates but will be required to make up such deficiencies without these credits being applicable toward the advanced degree. Students with a 2.75 junior-senior average, above-average scores on the Graduate Record Examination Aptitude Test, and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 239).

MINERAL ECONOMICS (MN EC)

453. NONMETALLIC MINERALS (3)
483. ECONOMICS OF THE METALS INDUSTRIES (3)
484. POLITICAL ECONOMY OF ENERGY AND THE ENVIRONMENT (3)
490. MINERAL VALUATION (3)
495. MINERAL INDUSTRIES DECISION MAKING (3)
500. ADVANCED READINGS IN MINERAL ECONOMICS (3) Selected readings on topics in mineral history, mineral economics research, applications of economic theory, mineral policy and law, and mineral exploration.
504. ADVANCED PRINCIPLES OF MINERAL ECONOMICS (3) Minerals as capital — taxation, conservation, and land tenure; operations of mineral markets; government policy; minerals in world trade and development.
506. ADVANCED STUDIES IN MINERAL COMMODITIES (3) Economic studies of selected mineral commodities and their products.
509. (Geol. 509) GEOLOGY AND ECONOMICS OF THE CONSTRUCTION MATERIALS (3) Occurrence, origin, and marketing of the mineral materials used by the construction industry. Economic and geologic evaluation of actual deposits.
510. (Geol. 510) GEOLOGY AND ECONOMICS OF THE INDUSTRIAL MATERIALS (3) Occurrence, ori-

gin, and marketing of the industrial minerals and evaluation of deposits. Chemical and ceramic raw materials emphasized.

513. APPRAISAL OF MINERAL RESOURCES AND ANALYSIS OF EXPLORATION DECISIONS (3) Mineral resource concepts; various quantitative methods for resource evaluation, including computer simulation; exploration economics and decision making within quantitative frameworks. Prerequisite: Mn.Ec. 490.

519. (Econ. 519) MINERAL POLICY ANALYSIS (3) Principles of policy analysis; cost-benefit and other analytical techniques; environmental analyses; case studies of legislative and administrative mineral policy issues.

523. ECONOMIC ANALYSIS OF METAL INDUSTRIES (3) Economic analysis of metal supply, demand, markets, industry conduct and performance, trade, domestic and foreign policies. Prerequisite: Econ. 302.

524. THE ECONOMIC ANALYSIS OF ENERGY MARKETS (3) Unified theory of exploration, development, and production; its application; domestic and foreign public policies; new sources; forecasting. Prerequisite: Econ. 302.

529. MINERAL INVESTMENT VALUATION (3) Investment analysis for mineral properties; including reserve estimation, capital budgeting techniques under risk, taxation, capital cost, and selected investment decisions.

530. CONTEMPORARY ISSUES IN MINERAL FINANCE (3) Critical investigation of current problems in mineral finance, including the issues of capital availability, and domestic and foreign mineral investment. Prerequisite: Mn.Ec. 490 or Fin. 405.

590. COLLOQUIUM (1-3)

MINERAL ENGINEERING MANAGEMENT (M E M)

R. V. RAMANI, *Section Chairman of Mineral Engineering Management*
104 Mineral Sciences
814-863-1621

Degree Conferred: M.Eng.

Graduate Faculty: Senior Members Aplan, Given, Lovell, Manula, W. Miller, Morley, Ramani, Rosenshine, Saperstein, Schenck, Stahl, and Stefanko.

Graduate Faculty: Associate Member Guild.

This program is designed to educate engineers for advancement into executive production management positions in the mineral and heavy construction industries, in development and sales in manufacturing companies, and in consulting firms. Its aim is to provide the knowledge, skills, and attitudes needed by persons to become innovators and responsible decision-making leaders. Participants are trained to create new designs, systems, and methods, and to plan, develop, and lead mineral industry organizations.

The content of appropriate courses is based upon specific problems encountered in the mineral industries. Such courses are offered by the departments which have combined their resources to offer this interdisciplinary effort: the Departments of Mineral Engineering (Mining and Petroleum and Natural Gas sections), Mineral Economics, Materials Science and Engineering, and Industrial and Management Systems Engineering. Courses in these areas and others may be selected by students and adapted to their individual interests.

The program emphasizes quantitative methods, principles of economics applied in mineral industries, and management.

Students are required to present a scholarly written report on a suitable project, the topic of which may be suggested by industry.

For admission a bachelor's degree in one of six engineering branches of mineral industry (mining, petroleum, mineral processing, metallurgy, fuel, and ceramics) or some other closely related field (in-

dustrial, civil, geological, mechanical, or chemical engineering) is required. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MINERAL ENGINEERING MANAGEMENT (M E M)

510. PRODUCTION AND OPERATIONS MANAGEMENT (3-9) Overall planning, design, and selection of equipment; programming and scheduling of mineral operations; statistical control of costs and production indices.

MINERAL PROCESSING (MN PR)

PETER T. LUCKIE, *In Charge of Graduate Programs in Mineral Processing*
108 Steidle Building
814-863-0373

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aplan, Austin, Hogg, and Lovell.

Graduate Faculty: Associate Members Luckie and Osseo-Asare.

This program is one of the options in which a graduate student in the Department of Mineral Engineering can receive an advanced degree. After ores and minerals are mined, they are usually processed to concentrate valuable components or remove undesirable components; then they are converted into useful products. The process engineering involves large plants which treat millions of tons of material per year at low cost, and is essential to such important industries as coal, power generation, steel, nonferrous metals, heavy chemicals, cement, and nonmetallic minerals. The world is facing shortages of energy, water, and raw materials, and the mineral processing engineering profession will play a key role in reducing and solving these problems. Increased efficiency and new ideas are urgently needed.

The training of a mineral processing engineer involves interdisciplinary combinations of chemistry, physics, the geological sciences, and engineering. This knowledge is then integrated with specialized knowledge — the creation, characterization, separation, agglomeration, and handling of mineral particles; the flotation and surface chemistry of mineral particles; and chemical extractions and separations — to provide the basis for developing and understanding the practical means of removal of valuable material from the rock body.

Pollution control is an important aspect of mineral processing because of the problems of disposal of large quantities of waste produced by the mining, metallurgical, cement, power, and heavy chemical industries, and the volume of process water used by these industries. Many air and water pollution control methods use equipment and processes originally developed for minerals treatment. Mineral processing methods are involved in the recycling and reuse of metals and other materials. A student may emphasize pollution control through course work and thesis research. The section also cooperates in the all-University interdisciplinary program leading to the Master of Science in environmental pollution control or the Master of Environmental Pollution Control.

The program of study for each student is decided by a study panel consisting of three faculty members and the student. The communication and foreign language requirement for the Ph.D. degree may be satisfied by reading proficiency in one foreign language. Students whose first language is English must demonstrate proficiency in German, Russian, or Japanese (or other language in which a major body of relevant technical literature exists). Students whose first language is not English will be required to show fluency in reading, speaking, comprehending, and writing English and may in some cases be required to demonstrate proficiency in one other approved language.

Graduates with bachelor's degrees in engineering, chemistry, chemical engineering, materials (ceramics, metallurgy), fuels, geological sciences, mathematics, mining, or physics are eligible for admission. Students with deficiencies may be required to make them up concurrently with their graduate

studies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds (such as industrial experience), abilities, and interests.

The following courses listed elsewhere are appropriate for Mineral Processing students: Mat.Sc. 411, 420; Metal. 401, 404, 414.

MINERAL PROCESSING (MN PR)

- 401. MINERAL PROCESS ENGINEERING (3)
- 413. MINERAL PROCESSING LABORATORY (1)
- 421. PARTICLE TECHNOLOGY LABORATORY (1-3)
- 424. COAL PREPARATION (3)
- 425. INTERFACIAL PHENOMENON AND FLOTATION (3)
- 426. (Metal. 426) HYDROMETALLURGY (3)
- 427. POLLUTION CONTROL IN THE MINERAL PROCESS INDUSTRIES (3)

- 501. INTERFACIAL PHENOMENA IN MINERAL SYSTEMS (3) Applications of surface phenomena to mineral engineering systems. Thermodynamics of surfaces, flotation, adsorption of detergents, electrical double layer, flocculation, dispersion. Prerequisite: Chem. 451.
- 502. FROTH FLOTATION AND AGGLOMERATION (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 501.
- 505. PHYSICAL SEPARATIONS IN MINERAL PROCESSING (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal, and other methods of mineral processing. Prerequisite: Mn.Pr. 401.
- 506. MINERAL PROCESS PLANT DESIGN (3-10) Process design and economy. Development and quantification of flow sheets. Integration of unit operations. Plant layout, equipment selection, and instrumentation. Prerequisite: Mn.Pr. 401.
- 507. (Metal. 507) HYDROMETALLURGICAL PROCESSING (3) Fundamental physico-chemical factors underlying the aqueous extraction and recovery of metals and non-metals from ores, minerals, and scrap metal. Prerequisite: Mn.Pr. (Metal.) 426.
- 508. MINERAL PARTICLE SYSTEMS (3) Creation, characterization, separation, and agglomeration of particles. Comminution, sizing, fractionation of powders; surface area, pore size determinations. Agglomeration and balling.
- 509. PARTICLE-FLUID DYNAMICS (3) Movement of particles in fluids, rheology of non-newtonian mineral suspensions, design of concentrating devices, fluidized beds, electrodynamic, magnetic separations.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

MINING ENGINEERING (MNG E)

LEE SAPERSTEIN, *Section Chairman of Mining Engineering*
 104 Mineral Sciences
 814-863-1619

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Bieniawski, Hardy, Lovell, Manula, Morley, Ramani, Saperstein, Stefanko, and Voight.

Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering (ore estimation, cost analysis and control, budgeting); mechanization and mine plant (unit operations, materials handling, continuous mining, mine electrical systems, power supply); development and exploitation methods (mine planning and layout, design of systems); mine management, production engineering (work and methods analysis, operations analysis); operations research, environmental control and health and safety (gas and dust technology, ventilation, air conditioning, hygiene, illumination, noise, safety, mine drainage, land reclamation, waste disposal); and rock mechanics (stress analysis, roof and ground control, penetration, fragmentation, subsidence).

Students who desire to obtain the Master of Engineering degree in mining engineering must take a minimum of 30 credits (including at least 12 credits at the 500 level) of appropriate courses in the major area and elective courses. A scholarly written report is also required. Programs of study are available in general mining engineering, rock mechanics, mine operations, research systems engineering, internal or external mine environmental control, mine health and safety; and emphasis can be given to any of the areas listed above.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by completion of courses in two languages or by completion of courses in one language and 6 credits of computer science. A thesis is required for the M.S. degree.

A bachelor's degree in mining engineering or a related engineering field is required for admission. Students may be required to make up deficiencies in their area of specialization. Certain basic related courses outside the department may be approved as part of the major. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 239).

MINING (MNG)

- 400. MINING AND OUR ENVIRONMENT (3)
- 402. MINE PLANT DESIGN (3)
- 403. MINE POWER SYSTEM AND COMMUNICATION DESIGN (3)
- 410. MINING ENGINEERING ANALYSIS (3)
- 411. MINE SYSTEMS ENGINEERING (3)
- 422. MINE VENTILATION AND AIR CONDITIONING (3)
- 431. ROCK MECHANICS (3)
- 441. SURFACE MINING SYSTEMS AND DESIGN (3)
- 451. ADVANCED MINING ENGINEERING (1-3)

- 502. MINE POWER SYSTEM PROTECTION (3) Protective circuitry, coordination, transient protection, and hazard reduction applied to mine power systems. Prerequisite: Mng. 403 or E.E. 425.
- 513. MINE COST ANALYSIS (3) Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records.
- 514. MINE OPERATIONS ANALYSIS (3) Application of operations research techniques in determining optimal design and operating policies for mine management. Prerequisite: Mng. 411.
- 515. MINE SYSTEMS SIMULATION (3) Principles and practices of probabilistic and deterministic simulation in the analysis of operating systems related to mills and mines. Prerequisites: Cmp.Sc. 401, Mng. 411.
- 531. RHEOLOGICAL AND STRENGTH CHARACTERISTICS OF ROCKS (3) Properties of rocks and their determination; failure theories; brittle to ductile transition; rheological behavior. Prerequisite: Mng. 431.
- 532. SPECIAL TOPICS IN ROCK MECHANICS (1-3) Behavior of rock under static loading; underground stress instrumentation; experimental stress analysis; design of mine openings; theories of subsidence.

542. **THEORY OF ROCK FRAGMENTATION (3)** Behavior of rock under dynamic loads intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E.Mch. 13, Mng. 30, Psy. 203.

543. **STRATA CONTROL ENGINEERING (3)** Theoretical considerations; convergence, abutments, subsidence; rockbursts; underground support systems; design of mine openings. Prerequisite: Mng. 431.

545. **ROCK MECHANICS INSTRUMENTATION (3)** Strain gauge circuitry, transducers, electrohydraulic servo installations, and integrated strain and force measuring systems as applied to rock mechanics. Prerequisite: Mng. 431.

590. **COLLOQUIUM (1-3)**

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

MUSIC (MUSIC)

MAUREEN A. CARR, *Director, School of Music*
232 Music Building
814-865-0431

Degrees Conferred: M.A., M.Mus.

Graduate Faculty: Senior Members Baisley, Brown, Fenner, and D. Miller.

Graduate Faculty: Associate Members J. Feldman, L. Feldman, P. J. Miller, and Perison.

The Master of Arts degree is academic in nature, and the program is directed toward musicological research. Admission requires the completion of a recognized music major or its equivalent, and a reading knowledge of one foreign language, either French or German. A thesis is required of all M.A. candidates. While the minimum requirement is 30 credits, the amount of course work necessary may exceed the minimum, depending on the needs and background of the student involved. At least 15 credits for the degree must be on the 500 level.

The Master of Music degree program is planned to provide professional, specialized emphasis in performance, composition, or conducting. Vocal performance students must demonstrate skill in foreign language diction. In addition to credit requirements, admission to the program is contingent upon departmental certification of the candidate's competence. According to the area of specialization, an audition or the submission of manuscripts is required. Arrangements for this may be made by the student with the department. While the minimum requirement is 36 credits, the amount of course work necessary may exceed the minimum, depending on the needs and background of the student involved. Students who lack the recommended upper-class courses in music may be required to take additional course work without receiving graduate credit.

The department sponsors musical activities, and candidates for both degrees are required to participate in positions of responsibility. All candidates for degrees are expected to be in residence for a minimum of three consecutive terms.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests. All applicants for graduate degrees must take the Graduate Record Examination, including the Advanced Music Examination.

The School of Music is an Associate Member of the National Association of Schools of Music.

MUSIC (MUSIC)

410. **MUSIC OF THE TWENTIETH CENTURY (3)**

412. **MUSIC OF THE BAROQUE PERIOD (3)**

413. MUSIC OF THE MIDDLE AGES (3)
414. MUSIC OF THE RENAISSANCE (3)
417. MUSIC OF THE CLASSICAL PERIOD (3)
418. MUSIC OF THE ROMANTIC PERIOD (3)
- *429. VOCAL STYLE (3 per term, maximum of 18) Fee \$100.
455. FORM AND ANALYSIS (2)
457. COMPOSITION (2 per term, maximum of 16)
459. ORCHESTRATION AND ARRANGING (3)
465. FORM AND ANALYSIS (2)
466. ADVANCED CONDUCTING (2 per term, maximum of 12)
467. OPERA WORKSHOP (1-6)
468. ADVANCED CHAMBER MUSIC (1-6)
470. CONTEMPORARY TECHNIQUES (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

500. INTRODUCTION TO MUSIC REFERENCE AND RESEARCH MATERIALS (3) A study of musicological reference and research materials in English and western European languages, with exercises in their use.
- *501. ADVANCED HARPSICHORD (3 per term, maximum of 18) Instruction in harpsichord playing; preparation for recital performance. Fee \$100.
- *503. ADVANCED ORCHESTRAL INSTRUMENTS (3 per term, maximum of 18) Study, repertoire building, and recital performance. Fee \$80.
- *504. INSTRUMENTAL AND VOCAL TECHNIQUES (1-2 per term, maximum of 12) Weekly instruction in a performance area other than the student's major, emphasizing performance techniques and repertoire.
- *511. ADVANCED PIANO (3 per term, maximum of 18) Piano literature of all periods for public performance. Fee \$80.
- *520. VOICE (3 per term, maximum of 18) Study, repertoire building, and recital performance. Fee \$80.
- *531. ADVANCED ORGAN (3 per term, maximum of 18) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee \$100.
555. ANALYTICAL TECHNIQUES (3) Advanced analysis of music of all periods.
- *558. FREE COMPOSITION (3 per term, maximum of 18) Composition: vocal and instrumental, standard or modern idioms.
- *560. ORCHESTRAL AND CHORAL CONDUCTING (3 per term, maximum of 18) Supervised conducting in selected performance situations, rehearsal techniques and comprehensive score analysis.
570. MUSIC TO 1750 (3) Studies of the development of musical styles from Gregorian chant through 1750, using reading, listening, and discussion.
572. SEMINAR IN MUSICOLOGY (3 per term, maximum of 9) Research in selected areas of music history.
580. STUDIES IN ORCHESTRAL LITERATURE (3) Selected studies in orchestral literature from the seventeenth century to the present.
581. STUDIES IN CHAMBER MUSIC LITERATURE (3) Selected studies in chamber music of all types from the seventeenth century to the present.
582. STUDIES IN KEYBOARD LITERATURE (3) The literature of major keyboard instruments from the sixteenth century to the present.

*Course may be scheduled only after consultation with the Director of the School of Music.

583. **STUDIES IN CHORAL LITERATURE (3)** Selected studies in choral literature of all types from the Renaissance to the present.
584. **STUDIES IN OPERATIC LITERATURE (3)** Studies in the development of the opera from 1600 to the present, treating both libretto and music.
585. **STUDIES IN VOCAL LITERATURE (3)** Selected studies in solo vocal literature of all periods.
589. **MUSIC SEMINAR (1-6)** Seminar in the history, art, and science of music, with readings, discussion, and performance.

MUSIC EDUCATION (MU ED)

J. DAVID BOYLE, *Coordinator*
263 Chambers Building
814-865-0418

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Boyle, Deihl, and Thompson.

Graduate Faculty: Associate Members Ramsey and Wooderson.

The School of Music offers graduate programs which help prepare students for careers in public-school music teaching, music supervision, college teaching, administration, or research. It is possible to include study in a number of these areas in the M.Ed. or D.Ed. programs.

Completion of a recognized music education major, or program leading to teaching certification in music, is a prerequisite for admission to the M.Ed. or D.Ed. programs. D.Ed. candidates will spend at least three consecutive terms in residence some time between admission to candidacy and completion of the degree program.

Applicants for the master's program who present a 2.75 junior-senior average and two satisfactory professional references will be considered for admission to the program in music education, provided they have appropriate course backgrounds and musical proficiency. Before each candidate's first enrollment, he or she will take a diagnostic examination in music education, music theory, and music history. The examination will provide one basis for planning the candidate's program. A comprehensive oral examination is to be passed upon completion of the course work and the master's paper.

Admission to the doctoral program requires a junior-senior minimum average of B; approximately half of any graduate credits of A quality; an interview prior to admission; five recommendations attesting to scholarship, musicianship, and ability to do independent study; and a minimum of two years of successful teaching experience in public or private schools. All applicants for graduate degrees must take the Graduate Record Examination, including the Advanced Music Examination.

The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

The School of Music is an Associate Member of the National Association of Schools of Music.

MUSIC EDUCATION (MU ED)

415. **WORKSHOP IN SELECTED MUSIC EDUCATION STUDIES (1-6)**
445. **METHODS, ELEMENTARY GRADES (3)**
446. **THE ELEMENTARY MUSIC SPECIALIST (3)**
448. **METHODS, JUNIOR AND SENIOR HIGH SCHOOLS (3)**
449. **STUDENT TEACHING IN THE ELEMENTARY SCHOOL (2-6)**
450. **STUDENT TEACHING IN THE HIGH SCHOOL (2-6)**
454. **ORCHESTRA AND BAND METHODS AND MATERIALS (3)**
455. **STUDENT TEACHING IN INSTRUMENTAL MUSIC (2-6)**
468. **THE TEACHING OF PIANO (3)**
469. **BAND AND ORCHESTRA TECHNIQUES (3)**

471. TEACHING MARCHING BAND (3)
 472. WIND INSTRUMENT MATERIALS (3)
 473. PSYCHOLOGICAL FOUNDATIONS OF MUSICAL BEHAVIOR (3)
 474. SELECTING AND DEVELOPING MEASURES OF MUSICAL BEHAVIOR (3)
 480. CHORAL PROGRAM IN THE SECONDARY SCHOOL (3)
 487. CHILDREN'S SONGS AND RECORDS (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
501. PROBLEMS AND PROJECTS IN MUSIC EDUCATION (1-6) Independent work on special topics of music education pertinent to the development of curricula, methods, and materials in music education. Prerequisite: 12 graduate credits in education (including music education).
525. PROSEMINAR: GRADUATE STUDY IN MUSIC EDUCATION (1-3) Bibliography; location and evaluation of reference materials; organization, form, style in preparing music education research reports and other papers.
555. RESEARCH METHODS IN MUSIC EDUCATION (3-6) Research methods and designs for problems in music education; techniques for studying cognitive, affective, and psychomotor responses to musical stimuli. Prerequisites: Mu.Ed. 525; Ed.Psy. 475; Ed.Psy. 406 or 407.
569. TRENDS IN INSTRUMENTAL MUSIC (3-6) Methods and materials for school instrumental ensembles.
570. CHORAL TECHNIQUE (3-6) Analysis and evaluation of choral materials appropriate for secondary school chorus; program building; practical rehearsal and conducting techniques. Prerequisite: 6 credits of vocal study.
572. INSTRUMENTAL PEDAGOGY (1-6) Independent work on special problems in instrumental music pedagogy. Prerequisite: practical experience and 10 graduate credits in music and/or music education.
573. THE MATERIALS OF APPRECIATION (3) Examination of written and recorded materials and appropriate techniques for developing appreciation of music at elementary, secondary, and college levels.
574. CONTEMPORARY MUSIC CURRICULA IN THE ELEMENTARY SCHOOL (3) Developing music curricula for the elementary school incorporating current theories, practices, materials and research data.
575. CONTEMPORARY MUSIC CURRICULA IN MIDDLE AND JUNIOR HIGH SCHOOLS (3) Instructional materials, procedures, and curricular activities, integration with other subjects.
576. MUSIC SUPERVISION (3) Current educational procedures in training music supervisors.
577. INTERNSHIP IN MUSIC SUPERVISION (3-6) Internship in schools under supervision of graduate faculty in music education. Prerequisites: C.&S. 581, Mu.Ed. 576.
581. CONTEMPORARY MUSIC EDUCATION (3) Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.
590. COLLOQUIUM (1-3)
591. INTERNSHIP IN MUSIC PERFORMANCE TECHNIQUES (1-6) Internship in selected school or music performance situations other than those in the district where the graduate student is employed.
594. PEDAGOGY OF MUSIC THEORY, READING, AND EAR TRAINING (3) Instructional theory and materials basic to teaching music theory, reading, and ear training. Musical instruments, audio-visual devices as aids. Prerequisite: 12 credits in music theory and/or harmony.
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

NUCLEAR ENGINEERING (NUC E)

WARREN F. WITZIG, *Head of the Department*
231 Sackett Building
814-865-4911

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Diethorn, Foderaro, Jester, Kenney, Klevans, Levine, Palladino, Pillay, Remick, Schultz, and Witzig.

Graduate Faculty: Associate Member Robinson.

Programs of study are individually tailored, and engineering is emphasized through the study of reactor principles — computational methods, transport theory, and nuclear design; plasma principles — waves, analysis, and fusion laboratory; shielding — Monte Carlo and transport methods; reactor systems design — thermal, mechanical, and control; reactor fuels — configuration, radiation effects, and fuel cycle management; isotope utilization — activation analysis, chemical processes including nuclear medicine; safety analysis — reactor siting, engineered safeguards, and environmental effects. The department offers three degrees at the master's level: M.Eng., M.S. with paper, and M.S. with thesis. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language and proficiency in English.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. General aptitude GRE test results are required. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

NUCLEAR ENGINEERING (NUC E)

- 401. INTRODUCTION TO NUCLEAR ENGINEERING (3)
- 402. NUCLEAR REACTOR DYNAMICS DESIGN (3)
- 405. APPLIED NUCLEAR AND RADIOCHEMISTRY (3)
- 408. RADIATION SHIELDING (3)
- 410-411. NUCLEAR REACTOR THEORY (3 each)
- 415. RADIONUCLEAR APPLICATIONS (3)
- 420. RADIOLOGICAL SAFETY (3)
- 425. (Bio.E. 425) RADIOGRAPHIC IMAGING (3)
- 428. RADIOACTIVE WASTE CONTROL (3)
- 430. DESIGN PRINCIPLES OF REACTOR SYSTEMS (3)
- 431. SYNTHESIS OF NUCLEAR SYSTEMS (3)
- 440. NUCLEAR ENGINEERING LABORATORY I (3)
- 441. NUCLEAR ENGINEERING LABORATORY II (3)
- 444. NUCLEAR REACTOR OPERATIONS LABORATORY (1)
- 490. (E.E. 490) INTRODUCTION TO PLASMAS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501. REACTOR ENGINEERING (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: M.E. 412 or Nuc.E. 430; Nuc.E. 411.

502. REACTOR ENGINEERING LABORATORY (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 411 (only if more than 1 credit of Nuc.E. 502 is taken).

503. THERMONUCLEAR ENGINEERING (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math. 452.

- 505. REACTOR INSTRUMENTATION AND CONTROL (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.
- 512. NUCLEAR FUEL MANAGEMENT (3) Nuclear fuel inventory determination and economic value through the fuel cycle. Emphasis on calculational techniques in reactor, optimization, and design. Prerequisite: Nuc.E. 411.
- 520. REACTOR ANALYSIS (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.
- 521. NEUTRON TRANSPORT THEORY (3) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.
- 540. (E.E. 540) THEORY OF PLASMA WAVES (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: Nuc.E. 490.
- 541. (E.E. 541) PLASMA THEORY (3) Advanced topics in kinetic theory, fluctuation theory, micro-instability, and turbulence. Prerequisite: Nuc.E. 540 (E.E. 540).
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

NURSING (NURS)

MARGARET A. NEWMAN, *In Charge of Graduate Program in Nursing*
 203C East Human Development Building
 814-863-0245

Degree Conferred: M.S.

Graduate Faculty: Senior Members Baltes, Gunter, and Newman.

Graduate Faculty: Associate Members Ettaro, Igou, Mandrillo, O'Brien, Rinehart, Susman, and Williamson.

The master of science degree in nursing is offered in recognition of the completion of a program which emphasizes productive scholarship and research in the preparation of the advanced nursing practitioner. The program is accredited by the National League for Nursing (NLN).

Each student must earn a minimum of 40 graduate credits with at least 30 earned as approved resident credits. A core of 9 credits in nursing theory, research, and models of practice is required of all students. Students may select an area of specialization in nursing practice for 21-25 credits (including electives), from among family health, community health and adult health and aging. In addition, 6-10 credits are required for statistics and thesis work; each student must complete a thesis.

Applicants should hold a baccalaureate degree in nursing from an NLN-accredited program and must submit the official results of the verbal and quantitative tests of the Graduate Record Examination. An overall grade-point average of 3.0 on a 4.0 scale is expected for undergraduate work. Courses in basic statistics and introduction to nursing research are required. Applicants who do not meet the established criteria may be considered on an individual basis.

NURSING (NURS)

- 405. OCCUPATIONAL HEALTH NURSING (3)
- 410. NURSING CARE OF THE FAMILY IN THE COMMUNITY (3)
- 425. SCHOOL HEALTH NURSING (3)
- 445. TRAUMA NURSING (3)

- 450. REHABILITATION NURSING (3)
- 455. ADVANCED MEDICAL NURSING (3)
- 460. ADVANCED SURGICAL NURSING (3)
- 464. DYING AND DEATH (3)
- 486. INTRODUCTION TO NURSING SERVICE ADMINISTRATION (2)
- 490. NURSING STUDY IN SPECIALIZED SETTING (1-12)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. ISSUES IN NURSING AND HEALTH CARE (2) Consideration of personal, social, political, economic, philosophical, ethical problems/questions and ways of confronting and resolving conflicts in professional practice.
- 510. THEORETICAL FOUNDATIONS OF NURSING (3) Examines current conceptual models in nursing and relationship of empirical data and existing theories to the development of nursing science.
- 511. DESIGN AND ANALYSIS OF CLINICAL STUDIES IN NURSING (3) Research design for problems of developing and evaluating nursing care programs, products, methods and procedures. Prerequisite: completion of (or concurrent with) a course in advanced statistics.
- 512. MODELS OF NURSING PRACTICE (3) Integration and application of current nursing theory and research to the development of a model of nursing practice. Prerequisite: Nurs. 510, 511.
- 522. MEDICATION MANAGEMENT (3) Therapeutic health maintenance principles based upon clinical pharmacology; drug therapy, management; drug metabolism, interaction, side effects, toxic effects, patient teaching. Prerequisite: basic background in principles of pharmacology.
- 530. CLINICAL PROCESS IN NURSING PRACTICE (1-10) Application of a model of nursing practice to a selected client population. Prerequisite: completion of advanced nursing theory courses in selected clinical areas.
- 550. TRANSCULTURAL HEALTH NURSING (3) Theoretical background for design, implementation, evaluation of nursing care to promote, maintain, and restore health, congruent with cultural patterns.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

NUTRITION (NUTR)

HELEN A. GUTHRIE, *In Charge of Graduate Programs in Nutrition*
 Henderson Human Development Building
 814-863-0772

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.; M.S. in Nutrition in Public Health

Graduate Faculty: Senior Members Guthrie, Shannon, Sims, and Wright.

Graduate Faculty: Associate Members Fosmire, Green, Kris-Etherton, Massaro, and Resurreccion.

Graduate programs in nutrition prepare students for careers in college teaching, research, industry, and government. The program in nutrition in public health prepares the student for work in public health and community agencies.

To satisfy the communication and foreign language requirement for the Ph.D. degree, students are expected to demonstrate competence in technical writing (e.g., Engl. 418) and spoken English.

For admission to a graduate program in nutrition, a student must have completed at least 6 credits in inorganic and organic chemistry, 3 each in biochemistry, microbiology, and human physiology, 4 in

other physical and biological sciences, and 8 in foods and/or nutrition. For admission to the program in nutrition in public health, an additional 12 credits in social sciences are required.

Students with a 2.80 junior-senior average, appropriate course backgrounds, and an acceptable score on the Graduate Record Examination (GRE) or Miller Analogies Test (MAT) will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Students with up to 8 credits of deficiency may also be admitted. Any deficiencies must be completed with a grade of B within two terms.

For other graduate courses in nutrition see A.Ntr. 501, Energy Metabolism, and A.Ntr. 503, Micronutrients: Nutrition, Metabolism, and Function, and A.I. 514, Animal Growth and Development. Current topics are presented as announced in Nutr. 597. Students are expected to participate in Nutr. 590, Colloquium, each term.

NUTRITION (NUTR)

400. INTRODUCTION TO NUTRITION COUNSELING (1-3)

420. EXPERIMENTAL FOODS (4)

421. CULTURAL ASPECTS OF FOODS (3)

422. ADVANCED FOODS (3)

452. NUTRITIONAL ASPECTS OF DISEASE (3)

453. DIET THERAPY (2)

454. LABORATORY METHODS IN NUTRITION (2)

456. COMMUNITY NUTRITION (3)

457. PRINCIPLES OF HUMAN NUTRITION (3)

458. APPLIED HUMAN NUTRITION (2)

459. ADVANCED NUTRITION (3)

490. FOODS AND NUTRITION SEMINAR (1)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

522. ADVANCED EXPERIMENTAL FOODS (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation.

530. PROBLEMS IN FOODS AND NUTRITION (1-6)

550. READINGS IN NUTRITION (3) Readings and reports of selected topics in nutrition.

551. SEMINAR IN NUTRITION (1-6) Selected topics and recent advances in nutrition.

552. NUTRITION IN DISEASE (2) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy.

555. FIELD WORK IN NUTRITION (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged.

556. THE SURVEY METHOD IN FOODS AND NUTRITION (2) Study of survey techniques as a tool in the assay of food adequacy and nutritional status.

557. INTERRELATIONSHIPS OF NUTRIENTS (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition.

558. PROTEIN NUTRITION (2) Classical concepts, recent developments and applied aspects of protein and amino acid nutrition and metabolism. Prerequisite: graduate standing in nutrition or related field.

560. PUBLIC HEALTH NUTRITION (3) Overview of public health nutrition field and profession: administration of public health nutrition programs, including program planning, implementation, and evaluation. Prerequisite: Nutr. 453, 456.

561. PUBLIC HEALTH NUTRITION: PROGRAMS/SERVICES (2) Organization of the nutrition component of programs administered by health agencies; application of knowledge and skills to effect planned change. Prerequisite: Nutr. 560.

- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

OPERATIONS RESEARCH (OR)

M. C. HALLBERG, *Chairman of the Committee on Operations Research*
 101 Weaver Building
 814-865-0467

Degrees Conferred: Students electing this option through participating graduate programs will earn a degree with a dual title at both the Ph.D. and the M.S. or M.A. levels, i.e., Ph.D. in (graduate program name) and Operations Research, or M.S. or M.A. in (graduate program name) and Operations Research.

Graduate Faculty: Senior Members Aggarwal, Antle, L. Austin, Biles, K. W. Crowley, Dinkel, Ensore, Farouq Ali, Gordon, Gould, Guild, Haight, Hallberg, Harkness, Hayya, Heitmann, Hottenstein, Hu, Ignizio, D. B. Johnson, Kleindorfer, C. G. Knight, Kochenberger, J. Lewis, Mann, Manula, McMurtry, Y. Mehra, W. Myers, J. Nelson, Parsons, Partenheimer, Ramani, Raphael, Rigby, Rosenshine, Shilling, Tilton, Turner, Willenbrock, and A. V. Williams.

Graduate Faculty: Associate Members Beierlein, Dunn, Kibler, W. Mills, E. Reutzel, T. A. Ryan, Sani, H. R. Thomas, and Zindler.

The operations research dual-title degree program option is administered by an Operations Research Committee, which is responsible for management of the program. The committee maintains program definition, identifies faculty and courses appropriate to the option, and recommends policy and procedures for its operation to the dean of the Graduate School. This dual-title degree program is offered as an option through graduate major programs in eight colleges. The option enables students from diverse graduate programs to attain and be identified with the tools, techniques, and methodology of operations research, while maintaining a close association with areas of application. Operations research is the analysis — usually involving mathematical treatment — of a process, problem, or operation to determine its purpose and effectiveness and to gain maximum efficiency. To pursue a dual-title degree under this program option the student must apply to the Graduate School and register through one of the following graduate major programs: agricultural economics, business administration, civil engineering, computer science, economics, educational administration, electrical engineering, forest resources, geochemistry and mineralogy, geography, industrial engineering, man-environment relations, mathematics, mineral economics, mining engineering, petroleum and natural gas engineering, and statistics.

For the Ph.D. degree with operations research option, in addition to those prescribed by the graduate major program, prerequisites for acceptance to the program without deficiency include the following or their equivalent: Math. 161, 162, 263, 240, and 72 or 250; Cmp.Sc. 101; and 6 credits in elementary or introductory micro- or macroeconomics. There are no prerequisites for admission to the M.S. or M.A. program option other than those that may be imposed by the participating graduate major programs.

To qualify for a dual-title degree after admission to the program option, students must satisfy the requirements of the graduate major programs in which they are registered, in addition to the minimum requirements, or their equivalent, in the operations research option.

The minimum requirements for the Ph.D. degree with operations research option are: (1) Mathematics — 9 credits minimum including real analysis (Math. 420) and linear algebra (Math. 441); (2) Statistics — 9 credits minimum with a 6-credit sequence in mathematical statistics (Stat. 409, 410) or in experimental statistics (Stat. 401, 402) and 3 credits in stochastic processes (Stat. 427); (3) Optimization — 12 credits minimum including linear programming I and II, mathematical programming I, and dynamic programming; (4) Processes — 9 credits minimum including inventory models, scheduling models, and waiting line models; (5) Computer Science — 6 credits minimum including numerical methods and digital simulation techniques; and (6) Open Areas (application and/or specialization) — 15 credits minimum.

For the M.S. or M.A. degree with operations research option, 18 credits are required from the areas of statistical methods, computer science, optimization (survey-level courses acceptable), processes (survey-level courses acceptable), and applications. (Application courses are those that involve problem solving through the use of decision methods.) At least 3 credits must be selected from each area. Particular courses may satisfy both the graduate major program requirements and those in the operations research option. A thesis may be required, the supervisor of which must be a member of the Graduate Faculty recommended by the chairman of the program granting the degree and approved by the Operations Research Committee as qualified to supervise thesis work in operations research. A paper or report may be written in lieu of the M.S. or M.A. thesis upon approval of the student's graduate major program. A student selecting the paper or report must take an additional 6 credits in the operations research program. It is the prerogative of the graduate major program to assign these credits to one or more of the following categories: statistical methods, computer science, optimization, processes, and applications.

A Ph.D. minor program in operations research is available for doctoral students in graduate programs who find it advantageous to include advanced quantitative methods of systems analysis in their program of study and have been approved to do so by their doctoral committee. To qualify for a minor in operations research, students must satisfy the requirements of their graduate major program and take at least 15 credits from the following areas: statistical methods or mathematical statistics, computer science, optimization, and processes. At least 3 credits must be taken from each of optimization and processes areas as listed below.

The doctoral committee is recommended by the graduate major program granting the degree. The chairman and at least two members of a doctoral committee must be members of the Graduate Faculty and approved by the Operations Research Committee as qualified to supervise doctoral theses in operations research. The Operations Research Committee is responsible for administering an examination in operations research which constitutes a portion of the comprehensive examination administered to the doctoral student in the program option, as well as to the candidate who chooses operations research as a minor field.

Courses of a like nature identified as the core of the program option have been given generic names and descriptions. Each such listing may be satisfied by one of the courses given under it.

OPTIMIZATION AREA

Linear Programming I An introduction to the theory and methodology of linear programming.

I.E. 405

Q.B.A. 451

Linear Programming II A further treatment of the theory and methodology of linear programming with emphasis on special formulations.

I.E. 510

Mathematical Programming I Introduction to optimization theory designed to provide the necessary fundamentals for nonlinear programming and more advanced studies in mathematical programming.

Q.B.A. 452

Mathematical Programming II An in-depth treatment of nonlinear programming and geometric programming with emphasis on both theory and applications.

Q.B.A. 540

Mathematical Programming III A seminar dealing with recent advances in mathematical programming.

Q.B.A. 550

Dynamic Programming Study of the concepts underlying model building and optimization of dynamic systems, with applications to engineering, economic, and environmental systems.

I.E. 519

Stat. 534 (M.E.R. 534)

Goal Programming Study of concepts and methods in analysis of systems involving multiple objectives, with applications to engineering, economic, and environmental systems.

I.E. 520

PROCESSES AREA

Inventory Models A study of inventory theory, deterministic and probabilistic models, single and multiproduct models in single- and multistage processes.

I.E. 508

Mgmt. 518

Scheduling Models Scheduling models with simultaneous job arrival and probabilistic job arrival, network scheduling and scheduling simulation techniques.

I.E. 507

Mgmt. 516

Waiting Line Models Theory of systems involving stochastic delay and stochastic service.

I.E. 509

Stat. 528

OPERATIONS RESEARCH (O R)

590. COLLOQUIUM (1-3)

PETROLEUM AND NATURAL GAS ENGINEERING (PNG E)

C. DREW STAHL, *Section Chairman of Petroleum and Natural Gas Engineering*
207 Mineral Sciences Building
814-865-6082

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Member Stahl.

Graduate Faculty: Associate Members Ertekin and Jacoby.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students who expect to enter graduate study in this program with a degree in another major should present 6 credits in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission. Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 239).

PETROLEUM AND NATURAL GAS (P N G)

400. THESIS (1-6)

410. APPLIED RESERVOIR ENGINEERING (3)

420. APPLIED RESERVOIR ANALYSIS (3)

425. PRINCIPLES OF WELL TESTING AND EVALUATION (3)

421. RESERVOIR ENGINEERING (3)

430. RESERVOIR MODELING (3)

440. FORMATION EVALUATION (3)

450. DRILLING DESIGN AND PRODUCTION ENGINEERING (3)

475. PETROLEUM ENGINEERING DESIGN (3)
480. PRODUCTION PROCESS ENGINEERING (3)
481. NATURAL GAS AND GASOLINE PLANTS (2)
485. ENGINEERING IN SECONDARY RECOVERY (3)
486. TERTIARY OIL RECOVERY METHODS (3)
493. ENGINEERING EVALUATION OF OIL AND GAS PROPERTIES (3)

510. SOLUTION OF THE PARTIAL DIFFERENTIAL EQUATIONS OF FLOW IN POROUS MEDIA (3) The application of mathematical techniques to solve the partial differential equations of steady and unsteady state flow in porous media. Prerequisite: Math. 405.
511. NUMERICAL SOLUTION OF THE PARTIAL DIFFERENTIAL EQUATIONS OF FLOW IN POROUS MEDIA (3) Differencing schemes for the partial differential equations of single-phase flow; application to flow of gas and mixing in porous media.
512. NUMERICAL RESERVOIR SIMULATION (3) Mathematical analysis of complex reservoir behavior and combination drives; numerical methods for the solution of behavior equations; recent developments. Prerequisite: P.N.G. 510.
513. ADVANCED NUMERICAL RESERVOIR SIMULATION (3) Compositional simulation; history-matching theory; simulation of basic processes involving heat and mass transfer in porous media. Prerequisite: P.N.G. 512.
514. OPTIMIZATION OF PETROLEUM RECOVERY PROCESSES (3) Optimum search methods, linear programming, nonlinear programming, dynamic programming, application to water-flooding, depletion drive, steam injection, gas cycling, miscible displacement. Prerequisite: P.N.G. 410.
515. ADVANCED OIL RECOVERY TECHNIQUES (3) Advanced oil recovery techniques including water-flooding, in situ combustion, steam injection, hot-water injection, and miscible-phase displacement.
519. DESIGN OF THERMAL RECOVERY PROJECTS (3) Suitability of reservoirs for thermal oil recovery; case histories; design of in situ combustion and steamfloods; thermal stimulation; shale oil recovery. Prerequisite: P.N.G. 515.
520. PHASE RELATIONS IN RESERVOIR ENGINEERING (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.
530. NATURAL GAS ENGINEERING (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycle; current developments. Prerequisite: P.N.G. 481.
550. ADVANCED ENGINEERING EVALUATION OF OIL- AND GAS-PRODUCING PROPERTIES (3) Selected topics of current research and development interest in formation evaluation, geophysical well logging and production economics. Prerequisites: P.N.G. 440, 493.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

NOTE: Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under Materials Science.

PHARMACOLOGY (PHARM)

ELLIOT S. VESELL, *Chairman of the Department*
The Milton S. Hershey Medical Center
Hershey, PA 17033
717-534-8285

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Berlin, Beyer, Connor, Fritz, Greene, Hayes, Jacob, Severs, and Vesell.

Graduate Faculty: Associate Members Dvorchik, Liu, Lloyd, Passananti, Rose, Schneck, Smith, and Summy-Long.

The graduate studies program in pharmacology is designed to give qualified students a combination of didactic instruction, informal direction, and laboratory experience which will enable them to obtain a firm foundation in the principles, methods, and contributions of pharmacology (defined broadly as the science of the multiple aspects of the interaction of chemical agents with biological systems). With this preparation, graduates of the program should be capable of designing and executing high-quality independent research, and of assuming positions of responsibility within the pharmacologic community.

The department offers studies in the general areas of drug metabolism, molecular pharmacology, endocrine pharmacology, neuropharmacology, cardiovascular-renal pharmacology, and clinical pharmacology. Primary emphasis is placed on the molecular mechanism by which drugs act in the body and by which the body transforms drugs.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required; reading knowledge of one or two foreign languages is recommended. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Two letters of recommendation are required, along with a curriculum vitae and Graduate Record Examination scores.

This program is offered only at The Milton S. Hershey Medical Center.

PHARMACOLOGY (PHARM)

501. PHARMACOLOGY (4) Lectures, discussions, and laboratory study of the mechanism of drug action in biological systems.

502. PHARMACOLOGY (4) Continuation of Pharm. 501.

504. DRUG METABOLISM (3) Study of chemical transformation of drugs within animal cells and drug-metabolizing enzymes present in liver microsomes performing this function. Prerequisite: Pharm. 501.

505. PHARMACOKINETICS (3) Quantitation of the time courses of absorption, distribution, metabolism and excretion of drugs in the intact organism. Prerequisites: Pharm. 501, 502, or 520.

510. MOLECULAR TURNOVER IN ANIMALS (3) In-depth consideration of the dynamic state of body constituents as applied to carbohydrates, lipids, nucleic acids, and particularly to proteins. Prerequisite: Bchem. 502.

511. MOLECULAR MECHANISM OF ACTION OF DRUGS (2) Series of lectures and informal discussion on the molecular mechanism of action of some drugs and their clinical applications. Prerequisite: Bchem. 502.

512. CLINICAL PHARMACOLOGY (3) Drug therapy of cardiovascular, renal, and neural diseases.

515. HUMAN GENETICS (2) Seminar-type presentations by students and staff on fundamental problems and current topics in human genetics.

520. PRINCIPLES OF DRUG ACTION (2) Detailed analysis of basic parameters governing drug actions.

- 525. **PHARMACOLOGY OF ANTITUMOR DRUGS (2)** Study of the mechanisms of antitumor drug action in biological systems. Prerequisite: Pharm. 501.
- 530. **PHARMACOLOGY OF PSYCHOTROPIC DRUGS (2)** Systematic analysis of the effects of psychotropic drugs.
- 540. **PHARMACOGENETICS (3)** Study of human responses to individual drugs.
- 549. **NEURAL SUBSTRATES FOR DRUG ACTION (2)** Correlation of the sites of action within the central nervous system where certain common drugs exert major effects. Prerequisites: Pharm. 501, 502.
- 550. **NEUROPHARMACOLOGY (2)** Study of mechanisms of action of drugs which alter neuronal transmission in the peripheral and central nervous systems.
- 571. **TECHNIQUES IN PHARMACOLOGICAL RESEARCH (2)** Classes will be comprised of lectures by the faculty of the Department of Pharmacology, followed by working demonstrations of the techniques.
- 575. **DEVELOPMENT OF RENAL DRUGS (3)** The development and clinical application of new therapeutic agents, using one or more prototype drugs as examples. Prerequisites: Pharm. 501, 502.
- 590. **COLLOQUIUM (1-3)**
- 596. **INDIVIDUAL STUDIES (1-6)**
- 597. **SPECIAL TOPICS (1-6)**

PHILOSOPHY (PHIL)

CARL R. HAUSMAN, *Head of the Department*
 247 Sparks Building
 814-865-6397

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Flay, Hausman, Johnstone, Kockelmans, Lingis, Rosen, Seeborn, Vaughn, and Verene.

Graduate Faculty: Associate Members Ginsberg, Helman, Price, and Tsugawa.

A thorough grounding in the history of philosophy is desirable for all students. Specialization is possible in areas (such as aesthetics, metaphysics, ethics, social philosophy, logic, and history and philosophy of science); in movements of thought (such as rationalism, empiricism, idealism, phenomenology, and existentialism); or in any of the major figures in the history of western philosophy. Specialization is also possible in a joint program with the Department of Mathematics in logic and the foundations of mathematics, and with the Department of Physics in philosophy of science. Undergraduate preparation to the extent of a strong minor is advisable. The department may waive the requirement of a thesis for an M.A. candidate.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

PHILOSOPHY (PHIL)

- 406. **MEDIEVAL PHILOSOPHY (3)**
- 408. **STUDIES IN SOCIAL AND POLITICAL PHILOSOPHY (3)**
- 410. **STUDIES IN GREEK PHILOSOPHY (3-6)**
- 411. **STUDIES IN MODERN PHILOSOPHY (3-6)**

412. STUDIES IN CONTEMPORARY PHILOSOPHY (3-6)
 413. PHILOSOPHY OF LITERATURE (3)
 414. AESTHETIC THEORY (3)
 417. STUDIES IN NINETEENTH-CENTURY PHILOSOPHY (3-6)
 419. PHILOSOPHICAL BACKGROUNDS OF AMERICAN THOUGHT (3)
 420. PHILOSOPHY OF HISTORY (3)
 421. STUDIES IN THE PHILOSOPHY OF SCIENCE (3)
 424. STUDIES IN PHILOSOPHY OF RELIGION (3)
 426. METAPHYSICS (3-6)
 427. ADVANCED ETHICS (3)
 428. (Math. 428) LOGICAL THEORY (3)
 429. SEMANTICS: PHILOSOPHY OF LANGUAGE AND SYMBOLISM (3)
 432. (S.T.S. 432) MEDICAL ETHICS (3)
 435. (S.T.S. 435) THE INTERRELATION OF SCIENCE, PHILOSOPHY, AND RELIGION (3)
 442. MODAL LOGIC (3)
 449. LOGIC IN PHILOSOPHY (3)
 494. (Ph.Ed. 494) MAN, WORLD, AND SPORT — A PHILOSOPHICAL INQUIRY (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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500. ETHICS: HISTORICAL AND SYSTEMATIC (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.
 504. SOCIAL AND POLITICAL PHILOSOPHY (3-6) Critical study of basic problems in their historical and functional setting.
 505. PHILOSOPHY OF WESTERN RELIGION (3-6) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.
 506. SEMINAR IN ANCIENT PHILOSOPHY (3-6) Study of one or more important men or movements in ancient philosophy.
 508. SEMINAR IN MODERN PHILOSOPHY (3-6) Men and movements in philosophy from the Renaissance through the nineteenth century.
 509. SEMINAR IN CONTEMPORARY PHILOSOPHY (3-6) Men and movements in twentieth-century philosophy.
 512. ADVANCED TOPICS IN PHILOSOPHY OF SCIENCE (3-6) Crucial problems in the theory of science and scientific method.
 513. (Psy. 513) PRINCIPLES AND METHODS OF EMPIRICAL SCIENCE (3) Scientific methodologies and their presuppositions, with special emphasis on behavioral and social sciences.
 514. SEMINAR IN NINETEENTH-CENTURY PHILOSOPHY (3-6) Study of a philosopher or philosophical movement of the nineteenth century.
 515. PHILOSOPHICAL METHOD (3-6) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.
 516. SEMINAR IN AESTHETICS (3-6) Problems and theories in the nature of art.
 526. SEMINAR IN METAPHYSICS (3-6) Formulation and analysis of metaphysical problems in the various fields of philosophy.
 530. PHILOSOPHY RESEARCH SEMINAR (1-12) Study of selected philosophical problems with an emphasis on techniques of philosophical research.
 543. PROPOSITIONAL AND PREDICATE LOGIC (3) The theory and metatheory of propositional logic, with an introduction to predicate logic.
 554. (Math. 554) LOGIC AND METAMATHEMATICS (3) Completeness, Lowenheim-Skolem and compactness theorems. First-order arithmetic, recursiveness, and the incompleteness and consistency of arithmetic. Prerequisite: Phil. 428.

- 590. COLLOQUIUM (1-3)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

PHYSICAL EDUCATION (PH ED)

KARL G. STOEDEFALKE, *Associate Dean for Academic Affairs*
 274 Recreation Building
 814-865-0407

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Buskirk, Cavanagh, Christina, Harris, Hodgson, Hunt, Kamon, Landers, Lucas, Lundegren, Mendez, Morehouse, Nelson, Shute, Stoedefalke, and Wickersham.

Graduate Faculty: Associate Members Alles, Eck, Eddy, Gallagher, Magnusson, Nicholas, Sabock, Scannell, Smith, St. Pierre, and Thompson.

The master's program is research-oriented and is designed to increase a student's professional competence as a teacher and future doctoral candidate, while the doctoral program is directed toward careers in research and in teaching at the advanced undergraduate and graduate levels in colleges and universities. The graduate programs are directed toward involvement of the student in gaining greater depth of understanding regarding the foundations of physical education. All degrees require experience with research to enable the student to better analyze problems, assess information, draw logical conclusions, and apply research findings.

Areas of specialization include (1) adapted physical education, (2) administration-curriculum-supervision, with a sub-area in sports administration, (3) biomechanics, (4) exercise specialist, (5) health education, (6) history of sport and physical education, (7) motor learning, (8) performance assessment, (9) physiology of exercise, (10) psychosocial foundations of physical activity, and (11) recreation and parks.

Admission to the graduate program requires a bachelor's or master's degree in physical education or its equivalent in comparable course work and acceptable performance on the Graduate Record Examination. Especially desirable is a concentration in the physical, biological, behavioral, or social sciences depending upon the intended area of specialization. Admission to doctoral study requires demonstrated research ability in the form of a thesis or published research. A student who has earned a master's degree in recreation and parks and meets the above requirement may enter a doctoral program in physical education with specialization in recreation and parks. Students must demonstrate proficiency in use of the English language. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language — French, German, Russian, Spanish, or another language upon petition.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Graduate Record Examination scores are required for all graduate program applicants.

See also Recreation and Parks.

HEALTH EDUCATION (HL ED)

- 405. PREVENTION AND CARE OF ATHLETIC INJURIES (3)
- 408. INJURY CONTROL (3)
- 411. PRINCIPLES AND METHODS OF TEACHING SAFETY EDUCATION (3)
- 421. INTEGRATING HEALTH EDUCATION INTO THE SCHOOL PROGRAM, K-12 (3)
- 443. ALCOHOL EDUCATION (3)
- 446. HUMAN SEXUALITY AS A HEALTH CONCERN (3)

- 450. HEALTH EDUCATION PRACTICUM (3-10)
 - 456. ADVANCED TECHNIQUES IN SCHOOL COMMUNITY HEALTH EDUCATION (3)
 - 457. CONSUMER HEALTH EDUCATION (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
511. (Anthy. 511) HEALTH IMPLICATIONS IN THE GROWTH AND DEVELOPMENT OF SCHOOL CHILDREN (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: HI.Ed. 215.
513. (Anthy. 513) HEALTH IMPLICATIONS IN MATURITY AND AGING (3) Changes in the human body in maturity and aging. Theories and mechanisms of physiologic aging with implications for health education. Prerequisite: HI.Ed. 511.
521. PROBLEMS IN SCHOOL HEALTH ADMINISTRATION (3) Critical concerns in the development and coordination of curriculum, policies, and evaluation of health education and services in school systems. Prerequisite: HI.Ed. 456.
530. (Ph.Ed. 530, Rc.Pk. 530) RESEARCH TECHNIQUES IN HEALTH AND PHYSICAL EDUCATION AND RECREATION (3) Research techniques, including methods, research design, techniques for data collection, as applied to relevant problems in the health education field.
552. CURRENT HEALTH EDUCATION ISSUES (3) Analysis of scientific and political foundations of current issues within health education tasks, with emphasis on research and action implications.

PHYSICAL EDUCATION (PH ED)

- 400. ADAPTED PHYSICAL EDUCATION (3)
 - 402. PHYSICAL EDUCATION FOR CHILDREN WITH LEARNING PROBLEMS (2)
 - 412. CONTEMPORARY PROBLEMS OF TEACHING PHYSICAL EDUCATION IN THE INNER CITY SCHOOLS (3)
 - 420. PSYCHOSOCIAL DIMENSIONS OF PHYSICAL ACTIVITY (3)
 - 442. SPORT IN ANTIQUITY (3)
 - 450. CURRENT RESEARCH LITERATURE IN PHYSICAL EDUCATION (3)
 - 452. METHODS, MATERIALS, AND PRINCIPLES OF PHYSICAL EDUCATION IN THE ELEMENTARY SCHOOL (3)
 - 455. STATISTICAL METHODS IN HEALTH, PHYSICAL EDUCATION, AND RECREATION (3)
 - 456. PHYSICAL FITNESS APPRAISAL (3)
 - 457. EXERCISE PRESCRIPTION (2)
 - 460. METHODS AND PRINCIPLES OF ATHLETIC COACHING (3)
 - 462. ADMINISTRATION OF ATHLETIC PROGRAMS (2)
 - 463. ACQUISITION OF MOTOR SKILLS (3)
 - 470. HISTORY AND THEORY OF DANCE IN EDUCATION (2)
 - 471. EUROPEAN AND AMERICAN FOLK DANCE (2)
 - 480. EXERCISE PHYSIOLOGY (3)
 - 483. MOTOR PATTERNS OF CHILDREN (3)
 - 484. SPORT BIOMECHANICS (3)
 - 489. INTRAMURAL ATHLETICS (3)
 - 490. MEASUREMENT AND EVALUATION IN HEALTH AND PHYSICAL EDUCATION (2)
 - 491. ORGANIZATION AND ADMINISTRATION OF HEALTH AND PHYSICAL EDUCATION IN SCHOOLS (3)
 - 494. (Phil. 494) MAN, WORLD, AND SPORT — A PHILOSOPHICAL INQUIRY (3)
 - 495. HISTORY OF SPORT IN AMERICAN SOCIETY (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
500. (Rc.Pk. 500) INDIVIDUAL STUDY AND RESEARCH PROJECTS (1-10) Prerequisite: Ph.Ed. 530.

520. **PSYCHOLOGY OF SPORT (3)** Study of man's psychological behavior in sport and physical activity; development of somatopsychic theory of physical activity. Prerequisite: 6 credits in psychology.
522. **SPORT IN SOCIETY (3)** Examination of the cultural phenomenon of sport; social behavior in sport; institution of sport and relationship with other social institutions. Prerequisite: 3 credits in sociology.
525. **SOCIAL PSYCHOLOGY OF SPORT (3)** Theory and research concerning the social-psychological basis for understanding social interaction and performance in team and individual sport settings. Prerequisite: 3 credits in social psychology at the 400 or 500 level.
530. (Hl.Ed. 530, Rc.Pk. 530) **RESEARCH TECHNIQUES IN HEALTH AND PHYSICAL EDUCATION AND RECREATION (3)** Research techniques, including methods, research design, techniques for data collection, as applied to relevant problems in the health education field.
532. **TESTS AND MEASUREMENTS IN PHYSICAL EDUCATION (3)** Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.
534. **STUDIES IN CURRICULUM CONSTRUCTION IN PHYSICAL EDUCATION (3)** Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction.
535. **MODERN FOREIGN SYSTEMS OF SPORT AND PHYSICAL EDUCATION (3)** Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.
550. **SEMINAR IN HEALTH AND PHYSICAL EDUCATION (1-6)** An in-depth analysis of current problems confronting the profession.
555. **INTERNSHIP IN SPORT ADMINISTRATION (3-10)** A supervised internship in the administration of interscholastic, intercollegiate, professional sport, or commercial sport-related enterprises. Prerequisite: 14 credits in sport administration, curriculum supervision area of specialization.
560. **ADMINISTRATIVE PROBLEMS OF PHYSICAL EDUCATION IN SCHOOLS (3)** Solutions to problems emerging from the administration of physical education in schools, fitting physical education in the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.
563. **MOTOR LEARNING (3)** Analysis of research evidence related to motor skills; characteristics of beginning and advanced performers; relevant learning principles.
565. **NEUROMUSCULAR PERFORMANCE (3)** Integrative action of the neural and muscular systems in effecting human movement with emphasis on motor performance. Prerequisites: Ph.Ed. 480, 490.
567. (Phsio. 567) **ADVANCED EXERCISE PHYSIOLOGY (3)** Physiological changes during exercise with emphasis on the effects of physical conditioning and training. Prerequisites: Biol. 472, Ph.Ed. 480.
568. (Phsio. 568) **ERGONOMICS (3)** Anthropometric, biomechanical, and physiological characteristics of working man and their importance in the man-machine-environment complex. Prerequisites: Biol. 472, Ph.Ed. 480; I.E. 408 recommended for engineering students.
575. **MOTOR PERFORMANCE OF THE HANDICAPPED (3)** Motor performance of physically handicapped and mentally retarded. Activities and therapeutic exercises for the formulation of individualized programs. Prerequisites: Cn.Ed. 409, E.E.C. 410.
576. **INTERNSHIP IN ADAPTED PHYSICAL EDUCATION (3)** Supervised internship in recreational, educational, or clinical situations; assessment of motor performances, evaluation of activities, and staff conference participation.
577. (Phsio. 577) **APPLIED CARDIOVASCULAR PHYSIOLOGY (2)** In-depth study of cardiovascular system physiology. Prerequisites: 4 credits in physiology at the 400 or 500 level.
580. (Phsio. 580) **ANALYSIS OF BODY COMPOSITION (2)** Study of the methods employed in the analysis of body composition. Prerequisite: Biol. 472 or 3 credits in physiology at the 400 or 500 level.

581. **BIOMECHANICS (3)** Kinetic and kinematic analyses of human motion utilizing electromyography and stroboscopic-photographic techniques. Prerequisite: Ph.Ed. 480.
582. **ADVANCED KINESIOLOGY (3)** Analysis of sports movements utilizing cinematography, electronic devices, and related research instruments.
583. **SPECIAL TOPICS IN BIOMECHANICS (1-6)** Critical review of current research in biomechanics, culminating in individual research projects. Prerequisite: Ph.Ed. 581 or 582.
584. **ELECTROMYOGRAPHIC KINESIOLOGY (3)** The theoretical background and practical application of electromyography in understanding human movement and the function of muscles. Prerequisites: Ph.Ed. 480, 484.
585. (Phsio. 585) **APPLIED PHYSIOLOGY: THERMAL (3)** Physiological mechanisms activated by exposure to environmental temperature. Prerequisite: Ph.Ed. 480 or 3 credits in physiology at the 400 or 500 level.
586. (Phsio. 586) **RESEARCH METHODS IN APPLIED PHYSIOLOGY (3)** Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.
587. (Phsio. 587) **APPLIED PHYSIOLOGY: AMBIENT PRESSURE (3)** Physiological mechanisms activated by exposure to environmental pressure. Prerequisite: Ph.Ed. 480 or 3 credits in physiology at the 400 or 500 level.
588. **SPECIAL TOPICS IN APPLIED PHYSIOLOGY (1-6)** Critical discussion and evaluation of current research in applied physiology. Prerequisite: Ph.Ed. 585.
590. **COLLOQUIUM (1-3)**
595. **PHILOSOPHY OF SPORT AND PHYSICAL EDUCATION (3)** Prerequisite: Ph.Ed. 491 or Rc.Pk. 465.
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**
602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

PHYSICS (PHYS)

ROLAND H. GOOD, JR., *Head of the Department*
104 Davey Laboratory
814-865-7533

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Barsch, Bleuler, Cole, Cutler, Feuchtwang, Fleming, Frankl, Freed, Good, Graetzer, Grotch, Henisch, Herman, Kazes, Kendall, Lang, Madjid, McCammon, McCubbin, Pliva, Polo, Pratt, Reed, Shaw, Strother, Thwaites, Tsong, Vedam, Whitfield, and Wiggins.

Graduate Faculty: Associate Members Chan, Lannin, Maynard, Page, and Sakurai.

Graduate instruction and research opportunities are available in atomic and molecular physics, nonlinear optics, field emission and field ion microscopy, many aspects of solid-state and surface physics, low-temperature physics, ionosphere and vacuum physics, acoustics, physics of biological compounds, nuclear physics, theoretical particle physics, quantum field theory, and general relativity. Work in some areas is conducted in cooperation with the Materials Research Laboratory, the Ionosphere Research Laboratory, and the Applied Research Laboratory. Thesis research toward applied options of the M.S. and the Ph.D. degrees is usually carried out in one of these laboratories.

For the Ph.D. degree, knowledge of a foreign language may be required depending on the area of research. For the M.S. and M.Ed. degrees, the nonthesis option is available subject to approval by the department head.

A bachelor's degree in physics or an allied field is required for admission to the M.S., D.Ed., and Ph.D. programs. Students with a 2.50 or higher junior-senior average in physics and mathematics will be considered, and the best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Exceptions may also be made for applicants for doctoral programs who have completed master's degrees at other institutions.

Admission and study programs for the M.Ed. degree are handled on an individual basis.

PHYSICS (PHYS)

400. INTERMEDIATE ELECTRICITY AND MAGNETISM (4)
 402. ELECTRONICS FOR SCIENTISTS (4)
 406. NUCLEAR PHYSICS (3)
 410. INTRODUCTION TO QUANTUM MECHANICS (3)
 412. SOLID STATE PHYSICS I (3)
 413. SOLID STATE PHYSICS II (3)
 419. (A.M., Math. 419) THEORETICAL MECHANICS (3)
 420. THERMODYNAMICS (3)
 421. KINETIC THEORY AND STATISTICAL MECHANICS (3)
 443. INTERMEDIATE ACOUSTICS (3)
 454. ATOMIC AND NUCLEAR PHYSICS (3)
 457. EXPERIMENTAL PHYSICS (1-2 per term)
 458. INTERMEDIATE OPTICS (4)
 461. (A.M., Math. 461) THEORETICAL MECHANICS (3)
 467. INTERMEDIATE ELECTRICITY AND MAGNETISM (3)
 471. QUANTUM THEORY OF ATOMS AND MOLECULES (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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510. GENERAL RELATIVITY (3) Foundations of general relativity; physics of metric spaces, tensor calculus; particle dynamics. Applications to stellar structure and cosmology. Prerequisites: Phys. 530; Phys. 525 or Math. 523.
 511. APPLICATIONS OF GENERAL RELATIVITY (3) Einstein's equations; empty and matter-filled spaces; conservation laws; Schwarzschild, Nordström-Reissner and Kerr solutions; solar system tests; gravitational waves. Prerequisite: Phys. 510.
 - 512-513. INTRODUCTION TO THE QUANTUM THEORY OF SOLIDS (3 each) Energy band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisites: Phys. 412, 517.
 517. STATISTICAL MECHANICS (3) Classical and quantum statistics; statistical thermodynamics; the Boltzmann transport equation; methods illustrated with applications to physical problems. Prerequisites: Phys. 420, 561.
 518. ADVANCED TOPICS IN THERMODYNAMICS AND STATISTICAL MECHANICS (3) Selected topics related to nonequilibrium thermodynamics, many-body problem, fluctuations, and statistical theory of random processes. Prerequisite: Phys. 517.
 524. PHYSICS OF SEMICONDUCTORS (3) Band structures, theory of electron and hole conduction, transport properties, excess carrier distributions, p-n junctions, metal-semiconductor contacts, semiconductor surfaces. Prerequisite: Phys. 412.
 525. METHODS OF THEORETICAL PHYSICS (3) Vector and tensor analysis; generalized coordinate systems; matrices and linear vector spaces of finite and infinite dimensionality; calculus of variations. Prerequisite: advanced calculus.
 526. METHODS OF THEORETICAL PHYSICS (3) Continuation of Phys. 525: complex variables; Hilbert space; Green's functions; orthogonal functions and boundary value problems. Prerequisite: Phys. 525.

530. **THEORETICAL MECHANICS (3)** Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.
532. **ADVANCED THEORETICAL MECHANICS (3)** Least action principle, canonical transformations, Lagrange and Poisson brackets, Hamilton-Jacobi equations, classical theory of fields. Prerequisite: Phys. 530.
533. **THEORETICAL ACOUSTICS (3)** Vibrating systems; transmission of disturbances through elastic and viscoelastic media. Prerequisite: Phys. 530.
550. **APPLIED GROUP THEORY (3)** Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510 or Phys. 525.
- 553-554. **NUCLEAR PHYSICS (3 each)** Theory of nuclear structure and nuclear reactions; intermediate-energy nuclear theory; pion physics. Prerequisite: Phys. 562.
557. **ELECTRICITY AND MAGNETISM (3)** Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric and magnetic properties of material media.
558. **ADVANCED ELECTRICITY AND MAGNETISM (3)** Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.
559. **GRADUATE LABORATORY (1)** Introduction to techniques and instrumentation used in modern physics laboratories. Includes experience in planning experiments and working in research laboratories.
- 561-562. **QUANTUM MECHANICS (3 each)** The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.
- 563-564. **ADVANCED QUANTUM MECHANICS (3 each)** Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.
571. **ATOMIC PHYSICS (3)** Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.
572. **MOLECULAR PHYSICS (3)** Electronic and nuclear motions in molecules, molecular spectra and structure. Prerequisite: Phys. 571.
590. **COLLOQUIUM (1-3)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)** (e.g., surface physics, tunneling theory, field-ion microscopy, liquid helium, superconductivity, vacuum physics, ion optics, nonlinear optics, many-body theory.)

PHYSIOLOGY (PHSIO)

ELSWORTH R. BUSKIRK, *Chairman of the Committee on Physiology*
119 Noll Laboratory
814-865-3453

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthony, Bullock, Buskirk, Eberhart, Gaffney, Harrison, Hodgson, Hollis, Jefferson, Kamon, LaNoue, Leach, McCarl, Mendez, Morgan, Mortimore, Mumma, Neely, Pegg, Rose, Scholz, Wangsness, Whitfield, Wickersham, and Zelis.

Graduate Faculty: Associate Members Etherton, Green, Hagen, Hawkins, Mashaly, Mitchell, Neff, Nicholas, Rannels, Schoolwerth, and Wenger.

This is an intercollege program designed to enable students to obtain an integrated series of courses encompassing both the fundamentals of physiology and advanced training in a specialized area. Courses can be taken at either The Milton S. Hershey Medical Center or at University Park.

Graduate instruction in physiology is under the direction of a program committee composed of graduate faculty representing several departments or groups at University Park actively participating in the physiology program — including the areas of animal industry, animal nutrition, biochemistry, bioengineering, biology, biophysics, physical education, psychology, veterinary science, and zoology — as well as the Department of Physiology at The Hershey Medical Center. The instructional staff is composed of faculty in those departments offering graduate courses in various areas of specialization in physiology. The program, including courses, laboratory experience, and original research, is designed for completion in three to four academic years. The communication and foreign language requirement for the Ph.D. degree may be satisfied by one of several options including intermediate knowledge of one foreign language.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

Deficiencies in chemistry, mathematics (through calculus), physics, or biological science must be made up early in the student's graduate program. All candidates (master's and doctoral) must complete a general basic laboratory course in physiology (combined cellular, mammalian, and comparative) before choosing an area of specialization. Possible areas of specialization are cardiovascular and respiratory physiology; cellular and subcellular physiology; comparative physiology; environmental physiology; exercise physiology; physiology of nutrition and metabolism; neurophysiology; and reproductive physiology. The graduate committee for majors shall be appropriately represented by members of the physiology program committee and those of the area of specialization who shall have the responsibility and jurisdiction for determining the course program and research acceptable in satisfying degree requirements. The nonthesis option is available for the M.S. degree.

The following courses, among others, are available for physiology majors, and their descriptions may be found under the offerings of several departments: Agro. 512, 545; A.I. 510, 514; A.Ntr. 401, 501; Anthy. 507; Bioch. 401, 402, 417, 437, 438, 501, 510, 511, 512, 519; Bio.E. 402; Biol. 409, 428, 437, 472, 473, 479, 538, 539, 550; Bphys. 430, 473, 587, 588; Cmp.Sc. 402, 410; D.Sc. 431; Ed.Psy. 400, 406, 506, 507; E.E. 569; Fd.Sc. 521; Hl.Ed. 511, 513; Meteo. 505; Micrb. 400, 401, 414, 508; Nuc.E. 415, 420; Nutr. 452, 457, 458, 459, 530, 552, 557; Ph.Ed. 456, 480, 565, 586, 588; Phys. 400, 402, 420; Psy. 402, 403, 455, 503; Stat. 451, 461, 462, 464; V.Sc. 405, 418, 525, 528, 535.

The following courses in anatomy and biochemistry are offered at The Milton S. Hershey Medical Center: Anat. 501, 502, 505, 510, 512, 513, 515, 530, 535, 542, 543, 545, 550, 590, 596, 597; B.Chem. 502, 503, 504, 513, 523, 551, 553, 590, 596, 597. Descriptions of these courses may be found under the designated program.

PHYSIOLOGY (PHSIO)

*520. MEDICAL PHYSIOLOGY (2) Cellular physiology including membrane permeability, bioelectric potentials, muscular contractions, secretion; metabolic physiology, including control of metabolism by hormones.

*521. MEDICAL PHYSIOLOGY (3) Organ physiology; examination of respiratory, renal, gastrointestinal and cardiovascular physiology.

*522. PHYSIOLOGY LABORATORY (1) Practical exercises in the areas of neuromuscular physiology, metabolism and endocrinology. Prerequisites: one year of biology, two years of chemistry, and one year of physics. Concurrent: Phsio. 520.

*523. PHYSIOLOGY LABORATORY (1) Practical exercises in the areas of cardiovascular, respiratory, renal and gastrointestinal physiology. Prerequisite: Phsio. 520. Concurrent: Phsio. 521.

*525. GENERAL PHYSIOLOGY (2) Cellular processes of accumulation membrane transport, bioelectric potentials, contraction, and secretion in erythrocytes, nerves, sensory receptors, muscles, glands, excretory organs.

*This course is offered at The Milton S. Hershey Medical Center.

- *530. **METABOLIC AND ENDOCRINE PHYSIOLOGY (3)** Regulation of carbohydrates, fatty acid and protein metabolism; regulation of hormone secretion; effects of hormones on water and cell metabolism.
- *532. **REPRODUCTIVE PHYSIOLOGY (3)** Physiology of mammalian reproductive systems, including synthesis, secretion and mechanism of action of the steroids and polypeptide hormones involved. Prerequisites: Phsio. 520, 521.
- *534. **HEART AND SKELETAL MUSCLE (2)** Discussion of structure, chemistry, and physiology of heart and skeletal muscle. Prerequisites: Phsio. 520, 521.
- *536. **GASTROINTESTINAL PHYSIOLOGY (2)** Mechanisms of absorption and secretion by stomach, intestine, pancreas, and gallbladder. Neural and hormonal regulation, bioelectric potentials, pathophysiology. Prerequisite: Phsio. 521.
567. (Ph.Ed. 567) **ADVANCED EXERCISE PHYSIOLOGY (3)** Physiological changes during exercise, with emphasis on the effects of physical conditioning and training. Prerequisites: Biol. 472, Ph.Ed. 480.
568. (Ph.Ed. 568) **ERGONOMICS (3)** Anthropometric, biomechanical, and physiological characteristics of working man and their importance in the man-machine-environment complex. Prerequisites: Biol. 472, Ph.Ed. 480; I.E. 408 recommended for engineering students.
571. (Biol. 571) **ANIMAL PHYSIOLOGY (2)** Mammalian cardiovascular system; mammalian neurophysiology; excitable tissue, sensory systems, motor systems, and autonomic system. Prerequisite: Biol. 472.
572. (Biol. 572) **ANIMAL PHYSIOLOGY (2)** Mechanisms involved in the activity and control of gastrointestinal function, respiration, and renal regulation of blood and body fluids. Prerequisite: Biol. 472.
573. (Biol. 573) **ANIMAL PHYSIOLOGY (2)** Hypothalamic-hypophyseal relationships. Reproductive cycle regulation, endocrine control of fluid balance, body temperature, energy homeostasis and metabolism of protein and minerals. Prerequisite: Biol. 472.
577. (Ph.Ed. 577) **APPLIED CARDIOVASCULAR PHYSIOLOGY (2)** In-depth study of cardiovascular system physiology. Prerequisite: 4 credits in physiology at the 400 or 500 level.
580. (Ph.Ed. 580) **ANALYSIS OF BODY COMPOSITION (2)** Study of the methods employed in the analysis of body composition. Prerequisite: Biol. 472 or 3 credits in physiology at the 400 or 500 level.
585. (Ph.Ed. 585) **APPLIED PHYSIOLOGY: THERMAL (3)** Physiological mechanisms activated by exposure to environmental temperature. Prerequisite: Ph.Ed. 480 or 3 credits in physiology at the 400 or 500 level.
586. (Ph.Ed. 586) **RESEARCH METHODS IN APPLIED PHYSIOLOGY (3)** Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.
587. (Ph.Ed. 587) **APPLIED PHYSIOLOGY: AMBIENT PRESSURE (3)** Physiological mechanisms activated by exposure to environmental pressure. Prerequisite: Ph.Ed. 480 or 3 credits in physiology at the 400 or 500 level.
- †590. **COLLOQUIUM (1-3)**
- †596. **INDIVIDUAL STUDIES (1-6)**
- †597. **SPECIAL TOPICS (1-6)**

†This course is also offered at The Milton S. Hershey Medical Center.

PLANT PATHOLOGY (PPATH)

SAMUEL H. SMITH, *Head of the Department*
211 Buckhout Laboratory
814-865-7448

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Ayers, Bloom, Boyle, Cole, Davis, Kingsolver, Leath, Lukeziec, MacKenzie, Merrill, P. Nelson, R. Nelson, Oswald, Pell, Schein, Schisler, Sherwood, Smith, Toussoun, and Wuest.

Graduate Faculty: Associate Members Frank, Hickey, McCarthy, Pennypacker, Petersen, Romaine, Royse, and Stouffer.

Plant pathology is the study of disease in plants and concerns the dynamic interaction between the plant, the causal agent (bacteria, fungi, viruses, nematodes, etc.), and their environments. A student prepares for a professional career in research, teaching, extension, or industry through advanced studies of the principles of plant infection, the physiology of disease in plants, the ecology of root diseases, the nature and inheritance of disease resistance in plants, epidemiology, ecology and physiology of air pollution injury to plants, or plant disease control by biological or chemical means. A student also may specialize in the nature and control of the diseases of forest trees, agronomic or horticultural crops, and commercial mushrooms. Advanced studies in applied mycology, related to the production of the commercial mushroom, also may be taken. Modern, well-equipped laboratories, controlled environment facilities and greenhouses, and well-developed field research areas are available for graduate study.

The Master of Agriculture degree is offered to provide professional training in plant pathology with more of a crop orientation than is available under the M.S. program. In addition to the courses required for an M.S. degree, further study in the areas of entomology and crop sciences is required. A thesis substitute, such as an internship report, or an adaptive or demonstrative activity whereby known technology or procedures are applied, is acceptable.

Competency in foreign language is not required for the Ph.D. degree; however, depending upon the nature of the thesis research and with the advice and consent of the doctoral advisory committee, competency in a foreign language may be judged to be an essential part of the doctoral studies of certain students.

For admission a student must present 42 credits in the natural sciences, including a minimum of 15 credits in the plant sciences and a minimum of 15 credits in mathematics, chemistry, or physics. Students with a strong background in agronomy, biochemistry, biophysics, botany, forestry, genetics, horticulture, or microbiology are usually well prepared for advanced study in plant pathology.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces and advisers that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

PLANT PATHOLOGY (PPATH)

- 401. THEORY AND CONCEPTS OF PLANT PATHOLOGY (3) *Merrill*
- 402. DISEASES OF ECONOMIC PLANTS (2 per term, maximum of 8) *Merrill*
- 403. INTRODUCTION TO EPIDEMIOLOGY (3) *Schein*
- 408. PLANT PATHOLOGICAL TECHNIQUES (3) *Wuest*
- 420. PLANT PATHOGENIC BACTERIA (3) *Lukeziec*
- 422. INTRODUCTION TO PLANT VIROLOGY (3) *Romaine*
- 424. ENVIRONMENTAL PATHOLOGY (3) *Davis*
- 429. PHYTONEMATOLGY (3) *Bloom*
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

501. CLINICAL PLANT PATHOLOGY (1-3) Diagnosis and prognosis of disease; observe and evaluate the implementation of control practices. Prerequisite: P.Path. 408. *Cole*
535. PRINCIPLES OF PLANT EPIDEMIOLOGY (3) Analytical methodology useful in describing pest epidemics on crop populations and the application of this information for pest control. Prerequisites: Agro. 512, P.Path. 401. *MacKenzie*
540. PLANT DISEASE CONTROL (3) Principles of plant disease control, including theoretical considerations involved in control by chemical and nonchemical means. *Cole*
541. PHYSIOLOGY OF PLANT DISEASE (3) Physiology of the diseased plant, including the host response to the pathogen and parasitic properties of the pathogen. Prerequisite: Biol. 443. *Lukezic*
542. EPIDEMIOLOGY OF PLANT DISEASES (4) Disease development in populations of plants, with emphasis on the impact of environment and control practices on rate of development. Prerequisite: 9 credits in plant pathology. *Pennypacker*
543. PATHOGEN VARIATION AND HOST RESISTANCE (3) Mechanisms and implications of genetic variation in plant pathogens related to breeding for disease resistance in plants by genetic means. Prerequisite: P.Path. 401, Agro. 411, or Hort. 407. *Ayers*
544. PATHOLOGICAL PLANT ANATOMY (3) Structural manifestations occurring in diseased plants. Prerequisite: Biol. 407. *P. E. Nelson*
560. PRINCIPLES OF PLANT PATHOLOGY (3) Open-ended discussions of concepts of plant pathology, with emphasis on their interrelationships and their significance to the science. *R. R. Nelson*
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

POLITICAL SCIENCE (PL SC)

JOHN D. MARTZ, *Head of the Department*
112 Burrowes Building
814-865-7515

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Albinski, Aspaturian, Brown, Butterworth, Chang, Eisenstein, Friedman, Gilberg, Harkavy, Keynes, Kochanek, Martz, Myers, and Spence.

Graduate Faculty: Associate Members Callaghy, Cimbala, King, Murphy, O'Connör, Sarvasy, and Williams.

Candidates for the M.A. will have comprehensive examinations in one of the following fields: American politics; comparative politics; international relations: politics, organization and law; political theory and methodology; and public administration. M.A. candidates may choose a thesis or an essay plan; both require that the student take course work in a primary and a secondary field from the above selections. Ph.D. candidates will take comprehensive examinations in three of the above fields, or in two departmental fields, and in a minor field or fields. Course work in the scope of the discipline and in methodology is required. The communication and foreign language requirement for the Ph.D. may be satisfied by competence in approved skills selected from among foreign languages, statistics or mathematics, and computer science.

Students with a 3.00 junior-senior average and appropriate course backgrounds, including at least the equivalent of 12 credits in political science, will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applications for admission to either the M.A. or Ph.D. degree program must include

transcripts, Graduate Record Examination scores (verbal and quantitative), a statement indicating career plans and proposed emphasis in Political Science, and at least two letters of recommendation. The applicant is responsible for soliciting letters from references. Letters of reference and the statement should be mailed directly to the department.

POLITICAL SCIENCE (PL SC)

401. POLITICAL BEHAVIOR (3) *King and O'Connor*
403. THE LEGISLATIVE PROCESS (3) *Keynes and King*
409. QUANTITATIVE POLITICAL ANALYSIS (3) *King and Williams*
412. INTERNATIONAL ECONOMIC POLITICS (3) *Harkavy*
413. GOVERNMENT AND POLITICS OF THE SOVIET UNION (3) *Aspaturian and Gilberg*
414. FOREIGN POLICY OF THE SOVIET UNION (3) *Aspaturian*
415. INTERNATIONAL ORGANIZATION: POLITICAL AND SECURITY FUNCTIONS (3-6) *Aspaturian, Brown, Butterworth, and Harkavy*
416. INTERNATIONAL LAW (3) *Butterworth*
417. AMERICAN LOCAL GOVERNMENT AND ADMINISTRATION (3) *Friedman, O'Connor, and Williams*
418. INTERNATIONAL RELATIONS THEORY (3) *Butterworth*
419. BUREAUCRACY AND PUBLIC POLICY (3) *Callaghy, Friedman, and Williams*
422. COMPARATIVE URBAN POLITICS (3) *Gilberg and Myers*
425. GOVERNMENT AND POLITICS OF THE AMERICAN STATES (3) *Friedman and O'Connor*
426. POLITICAL PARTIES (3) *King and Sarvasy*
427. POLITICAL OPINION (3) *O'Connor*
431. ANCIENT AND MEDIEVAL POLITICAL THEORIES (3) *Sarvasy and Spence*
432. MODERN WESTERN POLITICAL THEORY (3) *Sarvasy and Spence*
434. CONTEMPORARY POLITICAL THEORY (3) *Sarvasy and Spence*
435. FOUNDATIONS OF AMERICAN POLITICAL THEORY (3) *Sarvasy and Spence*
436. STUDIES IN 19TH- AND 20TH-CENTURY AMERICAN POLITICAL THOUGHT (3) *Sarvasy and Spence*
438. *National Security Policies* (3) *Brown and Myers*
442. AMERICAN FOREIGN POLICY (3) *Brown, Butterworth, and Harkavy*
443. AMERICAN SECURITY PROBLEMS (3) *Brown and Butterworth*
444. GOVERNMENT AND THE ECONOMY (3) *Friedman and Williams*
446. THE AMERICAN LEGAL PROCESS (3) *Eisenstein, Keynes, and Murphy*
447. CONSTITUTIONAL LAW: THE FEDERAL SYSTEM (3) *Keynes and Murphy*
448. CONSTITUTIONAL LAW: DEFENDANT'S RIGHTS (3) *Keynes and Murphy*
449. CONSTITUTIONAL LAW: INDIVIDUAL AND MINORITY RIGHTS (3) *Keynes and Murphy*
450. CANADIAN AND AUSTRALIAN POLITICS AND FOREIGN POLICIES (3) *Albinski*
451. COMPARATIVE POLITICAL ANALYSIS (3) *Albinski and Martz*
452. GOVERNMENTS AND POLITICS OF EASTERN EUROPE (3) *Gilberg*
453. POLITICAL PROCESSES IN UNDERDEVELOPED SYSTEMS (3-6) *Callaghy, Chang, Kochanek, and Myers*
454. GOVERNMENT AND POLITICS OF AFRICA (3) *Callaghy*
455. GOVERNMENTS AND POLITICS OF WESTERN EUROPE (3) *Gilberg*
456. POLITICS AND INSTITUTIONS OF LATIN-AMERICAN NATIONS (3) *Martz and Myers*
457. INTERNATIONAL POLITICS OF LATIN AMERICA (3-6) *Martz and Myers*
458. GOVERNMENT AND POLITICS OF EAST ASIA (3-6) *Chang*
459. GOVERNMENT, POLITICS, AND INTERNATIONAL RELATIONS OF SOUTH ASIA (3) *Kochanek*
462. MARXIST AND SOCIALIST POLITICAL THEORY (3) *Sarvasy and Spence*
466. COMPARATIVE FOREIGN POLICIES OF WESTERN EUROPE (3) *Brown*
468. INTERNATIONAL RELATIONS OF EAST ASIA (3) *Chang*
490. POLITICAL SCIENCE INTERNSHIP (1-3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
499. FOREIGN STUDY IN GOVERNMENT (2-6)

500. POLITICAL POWER (3-6) Subject announced prior to term offered.
509. SCOPE AND METHOD OF POLITICAL SCIENCE (3-6) *King and Williams*
512. COMPARATIVE POLITICAL SYSTEMS (3-9) *Albinski, Chang, Kochanek, and Myers*
513. SEMINAR IN COMPARATIVE POLITICAL PARTIES (3-6) Nature, function, organization, and leadership of parties; party systems, political culture, voting, and the institutional framework. *Albinski and King*
515. INTERNATIONAL POLITICS (3-6) *Butterworth and Harkavy*
516. SEMINAR IN INTERNATIONAL RELATIONS THEORY AND METHODOLOGY (3) A detailed analysis of major traditional and contemporary theory-building efforts and contemporary research techniques and orientations in international relations. *Butterworth and Harkavy*
517. INTERNATIONAL ORGANIZATION (3-6) *Aspaturian*
521. MODERN DEMOCRATIC POLITICAL THEORY (3-6) *Sarvasy and Spence*
523. SOVIET POLITICAL BEHAVIOR (3) Forces which shape rivalries for power; decision-making processes; areas of agreement and dissent. *Aspaturian and Gilberg*
524. FOREIGN POLICIES OF THE SOVIET BLOC (3-6) Major policies, the decision-making process, and the impact upon component members and external rivals for power. *Aspaturian and Gilberg*
525. COMPARATIVE AMERICAN STATE AND LOCAL POLITICS (3-6) Literature and research in comparative state and local political systems in the United States. *Friedman and O'Connor*
527. POLITICS AND LEGISLATIVE BEHAVIOR (3-6) Social factors which shape and determine the attitudes and decisions of American legislators and legislative bodies. *Keynes and King*
529. FEDERAL SYSTEMS (3-6) Features of the American federal system compared with those of other nations using the federal form. *Keynes and Friedman*
530. PUBLIC LAW (3-6) The nature of law and its role in modern society. *Eisenstein, Keynes, and Murphy*
532. EMPIRICAL POLITICAL THEORY (3-6) The impact of scientific method upon traditional political thought. *King, Spence, and Williams*
546. JUDICIAL PROCESS (3) Court functions in the political process; sources and limits of judicial power; perceptions of the judicial role; judicial decision making. Prerequisite: 12 credits in political science. *Eisenstein and Keynes*
554. AFRICAN POLITICAL SYSTEMS (3-6) Impact of European colonialism; cultural and anthropological factors in political development; modernization and analysis of selected problems in contemporary Africa. Prerequisite: 3 credits of comparative government or international relations at the 400 level. *Brown and Callaghy*
572. (Pub.A. 572) INTERNATIONAL DEVELOPMENT ADMINISTRATION (3-6) The execution of foreign policies through national and international public and private organizations. *Brown and LaPorte*
573. (Pub.A. 573) COMPARATIVE PUBLIC ADMINISTRATION (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Callaghy, LaPorte, and Myers*
574. (Pub.A. 574) SEMINAR IN THE ADMINISTRATION OF UNITED STATES FOREIGN AFFAIRS (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *Brown and LaPorte*
586. THEORY OF BUREAUCRATIC AND ADMINISTRATIVE POLITICS (3-6) The role of the executive in government and politics; theories of administrative organization, organization behavior, and decision-making processes. *Friedman and Williams*
594. READINGS IN POLITICAL SCIENCE (1-6) Directed readings in selected areas of the discipline.
595. RESEARCH IN POLITICAL SCIENCE (1-6) Directed research in selected areas of the discipline.
597. SPECIAL TOPICS (1-6)

POLYMER SCIENCE (PLMSC)

MICHAEL M. COLEMAN, *in Charge of Graduate Programs in Polymer Science*
325 Steidle Building
814-865-1288

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Harrison and Kline.

Graduate Faculty: Associate Members Coleman and Painter.

This program offers one of the areas in which a graduate student in the Department of Materials Science and Engineering may receive an advanced degree.

Research facilities are available for studies involving the synthesis, chemical and physical characterization, and mechanical properties of polymeric materials. Special instrumentation exists for research in the areas of vibrational spectroscopy, thermal analysis, X-ray, size-exclusion chromatography, and mechanical testing. Students may plan individual programs of study; coherent interdisciplinary programs are encouraged. The nonthesis option is available for the M.S. degree.

Competency in a foreign language is not required for the Ph.D. degree. Candidates are expected to demonstrate high proficiency in both written and spoken English.

Applications will be accepted from those having degrees in the basic or applied physical sciences or in engineering disciplines. Students with a 3.00 junior-senior average normally will be considered for admission. Exceptions may be made for students with special abilities, interests, or backgrounds, such as extensive industrial experience in polymer science.

POLYMER SCIENCE (PLMSC)

- 400. POLYMERIC MATERIALS (3)
- 406. INTRODUCTION TO THE MATERIALS SCIENCE OF POLYMERS (3)
- 407. POLYMER SCIENCE I (3)
- 409. POLYMER SCIENCE II (3)
- 410. MECHANICAL PROPERTIES OF POLYMERS AND COMPOSITES (3)
- 411. SMALL ANGLE X-RAY SCATTERING (2)
- 412. POLYMERIC MATERIALS LABORATORY — SYNTHESIS (2)
- 413. POLYMERIC MATERIALS LABORATORY — CHARACTERIZATION (2)
- 490. POLYMER SCIENCE SEMINAR (1)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

520. POLYMER CRYSTALS (2) Morphology, characterization, and properties of polymer crystals. Review of electron microscopy, thermal analysis, X-ray, density, and chemical degradation studies. Prerequisite: Plm.Sc. 407 or 409.

521. POLYMER VIBRATIONAL SPECTROSCOPY I (3) The description, theory, and application of infrared and Raman spectroscopies as applied to polymeric materials. Prerequisites: Math. 240; Chem. 33 or Plm.Sc. 406.

522. POLYMER VIBRATIONAL SPECTROSCOPY II (3) The theory and application of normal coordinate analysis as applied to polymeric materials. Prerequisites: Math. 260; Cmp.Sc. 101 or 201.

POULTRY SCIENCE (PTYSC)

KENNETH GOODWIN, *Head of the Department*
214 Animal Industries Building
814-865-3411

Degrees Conferred: M.S.

Graduate Faculty: Senior Members Buss, Goodwin, Graves, Leach, MacNeil, Mast, and Mueller.

Graduate Faculty: Associate Member Mashaly.

The department offers two types of degree programs: (1) an M.S. degree in Poultry Science, with one of the following major fields of interest: animal nutrition, behavior, food science, genetics, management, and physiology, or (2) an M.S. or Ph.D. degree in one of the following disciplinary interdepartmental programs: animal nutrition, ecology, genetics, and physiology. In either case, direction of the student's program will be by a faculty member in the Department of Poultry Science. For the Ph.D., reading ability in one foreign language is required.

Students with professional interests other than research may earn the M.S. in Poultry Science without doing a thesis; in this option, a paper on a selected professional problem is required for graduation.

Admission requirements include 30 credits in the biological and physical sciences (chemistry, mathematics, and physics). Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

POULTRY SCIENCE (PTYSC)

405. POULTRY PRODUCTION TECHNOLOGY (3)

462. (Biol. 462) ANIMAL BEHAVIOR — ETHOLOGY (3)

463. (Biol. 463, Psy. 463) ANIMAL BEHAVIOR LABORATORY (1-2)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

502. POULTRY NUTRITION (2-4) *Leach*

503. POULTRY FARM MANAGEMENT (3) An analysis of poultry farm management problems and the application of research methods to a specific problem.

582. (Biol. 582, Psy. 582) RESEARCH IN ANIMAL BEHAVIOR (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Graves and Hale*

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

NOTE: See *Animal Science* under "Other Graduate Courses and Options."

PSYCHOLOGY (PSY)

ROBERT M. STERN, *Head of the Department*
417 Moore Building
814-865-9514

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Borkovec, Cornwell, Craighead, Draguns, Farr, Gorlow, Guthrie, Hall, Kazdin, Landy, Leibowitz, Lundy, Mahoney, Martin, Mitzel, Nelson, Noble, Palermo, Piers, Ravizza, Ray, Seibel, Sherif, Shotland, Stern, Taylor, Thevaos, Thomas, Urban, Warren, and Weimer.

Graduate Faculty: Associate Members Brown, Jacobs, Mark, Newcombe, and Whaley.

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, cognition, human information processing, perception, psycholinguistics, verbal learning and memory, physiological and comparative, clinical, developmental and child, engineering and human factors, industrial-organizational, social.

The communication and foreign language requirement for the Ph.D. degree does not specify a foreign language, but a student must demonstrate proficiency in English.

Requirements for admission include a broad undergraduate preparation, a minimum of 9 credits in psychology, and a satisfactory graduate student rating on the Miller Analogies Test and the Graduate Record Examination (general and advanced). Students with a 3.40 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.40 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants with master's degrees will have their admission evaluated with emphasis on the quality of their graduate programs.

PSYCHOLOGY (PSY)

- 402. SENSATION AND PERCEPTION (3)
- 403. INTRODUCTORY PHYSIOLOGICAL PSYCHOLOGY (3)
- 404. CONDITIONING AND LEARNING (3)
- 405. THE EXPERIMENTAL PSYCHOLOGY OF VISUAL PERCEPTION (3)
- 408. COMPARATIVE PSYCHOLOGY (3)
- 409. TECHNIQUES IN LABORATORY EXPERIMENTATION (2-6)
- 410. HISTORICAL ANTECEDENTS OF PSYCHOLOGY (3)
- 411. SYSTEMS OF PSYCHOLOGY AND THE RECENT PAST (3)
- 412. ABNORMAL PSYCHOLOGY (3)
- 413. BIOGRAPHICAL PSYCHOLOGY (3)
- 414. HUMANISTIC PSYCHOLOGY (3)
- 415. INTERMEDIATE EXPERIMENTAL DESIGN (3)
- 417. SOCIAL PSYCHOLOGY (3)
- 418. MEASUREMENT OF PERSONALITY (3)
- 419. MEASUREMENT AND SCALING (3)
- 420. (Ling. 420) ADVANCED PSYCHOLINGUISTICS (3)
- 421. ADVANCED COGNITIVE PSYCHOLOGY (3)
- 425. CHILD PSYCHOLOGY (3)
- 426. ADOLESCENCE (2-3)
- 430. MEMORY AND VERBAL LEARNING (3)
- 431. INDUSTRIAL PSYCHOLOGY (3)
- 432. INTRODUCTORY ENGINEERING PSYCHOLOGY (3)
- 434. INFORMATION-PROCESSING LABORATORY (1-6)
- 435. (M.E.R. 435) ENVIRONMENTAL STIMULATION AND BEHAVIOR (3)
- 436. MENTAL HEALTH IN SCHOOLS (3)
- 437. PSYCHOLOGY OF ADJUSTMENT (3)

438. THEORY OF PERSONALITY (3)
 439. (Rl.St. 439) SACRED AND PROFANE THERAPIES (3)
 441. INDUSTRIAL MOTIVATION AND MORALE (3)
 444. ATTENTION AND INFORMATION PROCESSING (3)
 445. (I.F.S. 445) DEVELOPMENT THROUGHOUT ADULTHOOD (3)
 450. (Ed.Psy. 450) PRINCIPLES OF MEASUREMENT (3)
 455. PHYSIOLOGICAL PSYCHOLOGY LABORATORY (3)
 456. LABORATORY IN PSYCHOPHYSIOLOGY (2-4)
 457. EXPERIMENTAL SOCIAL PSYCHOLOGY (4)
 463. (Biol. 463, Pty.Sc. 463) ANIMAL BEHAVIOR LABORATORY (1-2)
 470. (I.F.S. 470) SOCIAL LEARNING FOUNDATIONS OF BEHAVIOR CHANGE (3)
 471. PSYCHOLOGY AND WOMEN (3)
 474. PSYCHOLOGY OF EXCEPTIONAL CHILDREN (3)
 479. (Rl.St. 479) SEMINAR: RELIGION AND CULTURE IN FREUDIAN THOUGHT (3)
 482. INTRODUCTION TO CLINICAL PSYCHOLOGY (3)
 483. THE PSYCHOLOGY OF FEAR AND STRESS (3)
 484. CLINICAL NEUROPSYCHOLOGY (3)
 489. PSYCHOLOGY OF CONSCIOUSNESS (3)
 490. PSYCHOLOGY PRACTICUM (1-10)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
503. PHYSIOLOGICAL PSYCHOLOGY (2-6) Correlations between structure and function of nervous system and human consciousness; laws and theories in fields of sensation, attention, association, affection, and thought. Prerequisite: 9 credits in psychology.
505. RESEARCH PROBLEMS IN PSYCHOLOGY (1-15) Prerequisite: 12 credits in psychology.
510. HISTORY OF THE HIGHER MENTAL PROCESSES (3) Stress upon theoretical, conceptual, and methodological problems involved in studying human thinking, language, memory, cognition, and other skills. Prerequisite: Psy. 410 or 411.
511. SEMINAR IN CONTEMPORARY PSYCHOLOGY (1-9) Critical review of readings on a topic of current interest, either in content or methodology, within psychology. Prerequisite: 9 credits in psychology.
513. (Phil. 513) PRINCIPLES AND METHODS OF EMPIRICAL SCIENCE (3) Scientific methodologies and their presuppositions, with special emphasis on behavioral and social sciences.
515. ADVANCED STATISTICS IN PSYCHOLOGY AND EDUCATION (3) Correlation theory and methods, discriminant analysis, and factor analysis; applications to mental test theory. Prerequisite: Psy. 415 or Ed.Psy. 506.
517. ADVANCED SOCIAL PSYCHOLOGY (3) Problems of theory and of research methods with emphasis on persisting issues relevant to contemporary developments in social psychology. Prerequisites: Psy. 417; Psy. 15 or Stat. 200.
518. PROJECTS IN EXPERIMENTAL PSYCHOLOGY (2-4) Individual experimental projects; seminars on experimental design and instrumentation.
520. (Ling. 520) SEMINAR IN PSYCHOLINGUISTICS (3) Consideration of theoretical and research issues relevant to psychological aspects of language sounds, syntax and semantics, and other cognitive support.
522. PERSONNEL SELECTION AND APPRAISAL (3) Evaluation of models for personnel selection, placement, and performance appraisal in business and industry. Prerequisites: Psy. 431, Psy. 450 (Ed.Psy. 450).
523. SOCIAL-ORGANIZATION PSYCHOLOGY IN INDUSTRY (3) Analysis of the role of social and organizational variables as they affect employee performance and employee attitudes. Prerequisite: Psy. 431.

527. STATISTICAL INFERENCE AND EXPERIMENTAL DESIGN (3) Probability theory, sampling distributions, analysis of variance and covariance, analysis of trend, nonparametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 506.
529. (I.F.S. 529) SEMINAR IN CHILD DEVELOPMENT (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.
531. SEMINAR IN PERFORMANCE THEORY (3-9) Topics in theory and research on human performance in perceptual-motor and information-processing tasks. Prerequisite: Psy. 432.
533. ADVANCED ENGINEERING PSYCHOLOGY (3) Analysis of the role of the human operator in man-machine systems. Prerequisite: Psy. 432.
534. PRACTICUM IN INDUSTRIAL/ORGANIZATIONAL PSYCHOLOGY (1-3) Supervised application of psychological principles in industrial and governmental settings. Prerequisite: Psy. 431.
535. DEVELOPMENTAL PSYCHOLOGY (2-3) Developmental principles and concepts applied to psychological processes, with special reference to the experimental literature. Prerequisite: 9 credits in psychology.
536. (I.F.S. 536) RESEARCH METHODS IN DEVELOPMENTAL PROCESSES (3) Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology, and a course in statistics.
538. PSYCHOLOGY OF PERSONNEL DEVELOPMENT (3) Industrial training in relation to psychological learning theory and experimental findings. Prerequisite: Psy. 431 or Ed.Psy. 421.
539. SEMINAR IN MOTIVATION AND EMOTION (3-9) Systematic status of instinct, drive, motive, will, purpose; methodology and results of physiological, experimental, and clinical investigation of basic drives.
540. SEMINAR IN CLINICAL PROBLEMS (1-9) Contemporary psychological theory, research, and methodology in relation to clinical psychology. Prerequisites: Psy. 542, 560.
541. PERSONALITY THEORY (3-4) Contemporary theories of personality; relevant research. Prerequisite: Psy. 438.
542. PSYCHOPATHOLOGY (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisite: Psy. 412.
543. RESEARCH DESIGN IN CLINICAL PSYCHOLOGY (3) Experimental and quasi-experimental designs, methodological problems, and techniques of experimental control in clinical psychology research. Prerequisite: 3 credits of statistics.
544. PSYCHOLOGICAL HYPNOSIS (3) Theory and research in psychological hypnosis. Techniques in the induction and clinical applications of hypnosis.
545. SEMINAR IN VERBAL LEARNING AND VERBAL BEHAVIOR (1-9)
549. (I.F.S. 549) DEVELOPMENTAL THEORY (3) Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.
555. THEORY AND PRACTICUM IN CLINICAL ASSESSMENT (3-9) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of testing procedures and clinical interviewing. Prerequisites: Psy. 541 or 542, and a course in measurement.
558. CLINICAL CHILD PSYCHOLOGY (3-9) Psychopathology of childhood; theories of etiology; diagnosis and treatment. Prerequisites: Psy. 555, 561.
559. (S.Psy. 559) THE INDIVIDUAL PSYCHOLOGICAL EXAMINATION (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.
560. PRACTICUM IN CLINICAL METHODS (1-6) Supervised practice in the Psychology Clinic, including assessment, therapy, report writing, and staff participation. Prerequisite: Psy. 555.

561. **CLINICAL PRACTICUM WITH CHILDREN (1-6)** Diagnosis and counseling of child-parent problems of learning and adjustment. Prerequisites: Psy. 425, 426, 555.
563. **BEHAVIOR MODIFICATION I (3)** Conceptual foundations of principles, assessment methods, and research strategies.
564. **BEHAVIOR MODIFICATION II (3)** Survey and empirical evaluation of treatment strategies. Prerequisite: Psy. 563.
565. **SEMINAR IN COMMUNITY PSYCHOLOGY (3)** Application of social psychological research methods and principles to prevention and alleviation of behavior disorders in family and community settings.
566. **CULTURAL PSYCHOLOGY (3)** Experimental and descriptive research on culture and behavior in both Western and non-Western settings. Prerequisites: Psy. 417, 438, and 6 credits of statistics.
569. **ADVANCED THEORY AND PRACTICUM IN COUNSELING AND PSYCHOTHERAPY (3-9)** Theoretical issues, research, and practicum experience in psychotherapy.
571. **SEMINAR IN SOCIAL PSYCHOLOGY (3-9)** Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research.
580. **THEORY AND CONSTRUCTION OF ATTITUDE SCALES (3)** Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.
582. (Biol. 582, Pty.Sc. 582) **RESEARCH IN ANIMAL BEHAVIOR (2-6 per term)** Research in special areas of animal behavior involving field or laboratory work.
583. **DESIGNING RESEARCH IN SOCIAL PSYCHOLOGY (3)** Comparative analysis of major methodological approaches including laboratory experiments, field experiments, quasi-experiments, and surveys. Prerequisites: Psy. 417; 3 credits in statistics.
584. **ATTITUDE FORMATION AND CHANGE (3)** Theory and method in research on attitude formation and change with emphasis on critical analysis and research problems. Prerequisites: Psy. 417; 3 credits in statistics.
585. **INTERACTION PROCESSES WITHIN AND BETWEEN GROUPS (3)** Small group processes as context for behavior and for self system. Emphasis on theory and research in laboratory and field. Prerequisites: Psy. 417; 3 credits in statistics.
586. **THE SOCIAL PSYCHOLOGY OF COLLECTIVE ACTION (3)** Social movements, crowds, audiences, and large groups explored for their impact upon the behavior of the individual member. Prerequisite: Psy. 417.
589. **PROBLEMS IN CLINICAL RESEARCH (1-6)** Prerequisite: Psy. 415.
590. **COLLOQUIUM (1-3)**
591. **SEMINAR ON TEACHING PSYCHOLOGY (1-3)** Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

PSYCHOSOCIAL SCIENCE (PS SC)

ROBERT COLMAN, *In Charge of the Graduate Program in Psychosocial Science*
The Capitol Campus, Middletown, PA 17057
717-948-6034

Degree Conferred: M.Ps.Sc.

Graduate Faculty: Senior Members Hudson, Lear, Masters, Nichols, and Whittaker.

Graduate Faculty: Associate Members Barton, Colman, Dexter, and Towns.

The program emphasizes practicum experience to equip students with necessary skills to cope effectively with the problems facing communities. Graduates of the program should be able to recognize problems, to outline and implement possible solutions to these problems, and to evaluate the effectiveness of the solutions. To perform these functions the student must be aware of contemporary community needs, the impact of the community structure upon its individual members, and the techniques best suited to initiate productive change. Problems in drug abuse, delinquency, unemployment, housing, and other areas affecting the individual may be approached from a community agency base or from less formal community groups dealing with the problems.

The student is required to take 45 credits, 25 at the 500 level. The required practicum experience is field work under the supervision of a faculty member. A paper is required and will be defended orally before a committee of two faculty members and a staff member from the practicum site.

For admission, a student must have received a baccalaureate degree from an accredited institution with residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. Most applicants have degrees in psychology or sociology; however, experience in community agencies is weighed for applicants from other disciplines. Ordinarily, applicants are expected to be familiar with elementary statistics and may be requested to make up any deficiency without graduate credit. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Required courses include: So.Sc. 510, 520; Ps.Sc. 470, 500, 511, 521, 530. A student may select an emphasis in public agency, community mental health, community organizing, behavioral management, or urban society. The majority of the courses are offered in the evening.

This program is offered only at Capitol Campus. Details of application procedures should be requested from Admissions, The Capitol Campus, Middletown, PA 17057.

PSYCHOSOCIAL SCIENCE (PS SC)

- 401. SEMINAR IN PSYCHOSOCIAL SCIENCE (4)
- 407. SMALL GROUPS (4)
- 421. BEHAVIOR MODIFICATION (4)
- 430. SOCIAL JUDGMENT (4)
- 461. THEORIES AND MODELS OF COUNSELING (4)
- 470. ADVANCED STATISTICAL AND DESIGN METHODS (4)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

500. THEORIES AND ISSUES IN COMMUNITY PSYCHOLOGY (3) Contemporary issues in community psychology will be discussed within the framework of its development from clinical and social psychology.

511. PSYCHOPATHOLOGY IN A SOCIAL CONTEXT (3) Psychopathology in the context of other forms of social deviancy, with attention to both social and individual concomitants of deviancy.

512. THEORIES AND MODELS OF PSYCHOTHERAPY (3) Survey of methods/theories used to treat mental illness or to change dysfunctional behavior. Prerequisites: Ps.Sc. 461, 511.

521. PRACTICUM (3-9) Experience in a field setting with problems confronting both clients and social welfare agencies. Prerequisites: So.Sc. 510, 520.

- 530. RESEARCH (1-6) Supervised research on a master's paper. For degree candidates only.
- 535. BEHAVIORAL MANAGEMENT (3) Analysis of the social determinants of behavior and behavioral ecology. Emphasis on data collection and evaluation techniques. Prerequisite: Ps.Sc. 421.
- 570. ADVANCED EXPERIMENTAL DESIGN (3) A survey of advanced statistical methods and experimental design techniques for community psychology, behavior management, and the social sciences. Prerequisites: Ps.Sc. 470, So.Sc. 520.
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

SOCIAL SCIENCE (SO SC)

- 440. THE CITY (4)
- 443. SOCIAL CONFLICT (4)
- 510. CHANGE PROCESSES (3) Social change as it takes place within institutions and communities.
- 520. TECHNIQUES IN ACTION RESEARCH (3) Methods for evaluating programmatic change. Prerequisite: So.Sc. 320.
- 531. THE FUNCTIONING NEIGHBORHOOD (3) A study of small communities and techniques for observing them, coupled with field experience in participant observation of a specific neighborhood.
- 532. COMMUNITY ORGANIZING: CONFLICT AND CHANGE (3) The development of local issues and strategies for organizing around them.
- 533. PROBLEMS OF THE DISENFRANCHISED (3) Problems confronting minority or low-power groups, with an emphasis on the poor, blacks, and women.
- 541. THE ORGANIZATION OF HUMAN SERVICES (3) Divisions of labor among social agencies; internal and external factors affecting the ordering of priorities.
- 542. SOCIAL STRATIFICATION (3) Empirical and theoretical examinations of inequalities in wealth, prestige, and power.
- 543. COMPLEX ORGANIZATIONS: CHANGE AND RESISTANCE (3) Structure and function in large organizations and case studies of change.
- 590. COLLOQUIUM (1-3)
- 597. SPECIAL TOPICS (1-6)

PUBLIC ADMINISTRATION (PUB A)

ROBERT J. MOWITZ, *Director of the Institute of Public Administration*
 211 Burrowes Building
 814-865-2536

Degree Conferred: M.P.A.

Graduate Faculty: Senior Members LaPorte, Lee, Mowitz, and Poister.

Graduate Faculty: Associate Members McDavid, Stevens, and Stipak.

All candidates take a core program consisting of seven seminars which cover the theoretical, methodological, and technological components of public management science. An additional 9 credits may be elected, permitting the student to focus upon such areas as general public administration, systems analysis, management information systems, urban systems administration, natural resources administration, human resources administration, or any other related substantive area. Course work may be taken at University Park or at the Radnor Center for Graduate Studies. Admission is authorized by the University Park program director.

Candidates for admission ordinarily have at least 12 credits of undergraduate work in the social sciences. Candidates for the degree may be required to take some courses without graduate credit in order to complete a major designed for their professional needs.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Scores from the Graduate Record Examination (aptitude test) and two letters of recommendation are required.

PUBLIC ADMINISTRATION (PUB A)

400. INTRODUCTION TO THE AMERICAN ADMINISTRATIVE SYSTEM (3) *Mowitz*
 402. METHODS OF PROGRAM ANALYSIS (3) *McDavid, Poister, and Stipak*
 403. PUBLIC MANAGEMENT TECHNOLOGY (3) *LaPorte and Lee*
 404. URBAN MANAGEMENT (3) *Lee, McDavid, Poister, and Stipak*
 445. ADMINISTRATIVE LAW (3) *Lee and Mowitz*
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
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570. ADMINISTRATION IN MULTI-JURISDICTIONAL SYSTEMS (3) Analysis of multi-jurisdictional constraints on administration; design of strategies for developing and executing programs in a pluralistic institutional setting. *LaPorte, Lee, McDavid, and Poister*
 571. THEORY OF PUBLIC ADMINISTRATION (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice. *Mowitz, Stevens, and Stipak*
 572. (Pl.Sc. 572) INTERNATIONAL DEVELOPMENT ADMINISTRATION (3-6) The execution of foreign policies through national and international public and private organizations. *LaPorte*
 573. (Pl.Sc. 573) COMPARATIVE PUBLIC ADMINISTRATION (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *LaPorte*
 574. (Pl.Sc. 574) SEMINAR IN THE ADMINISTRATION OF UNITED STATES FOREIGN AFFAIRS (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *LaPorte*
 575. GOVERNMENT MANPOWER MANAGEMENT (3) Government personnel systems; current trends and problems; essentials of recruitment, classification and pay, ratings, supervision, training, and discipline. *LaPorte, Lee, and Stevens*
 576. GOVERNMENT FISCAL DECISION MAKING (3) The role of the executive in fiscal planning; budget preparation; expenditure control; tax assessment and collection; investment of public funds. *LaPorte and Lee*
 577. ORGANIZATION AND SYSTEMS MANAGEMENT (3) Principles of government organization; management surveys; work measurement; methods of achieving efficiency and economy. *Mowitz, Stevens, and Stipak*
 578. URBAN ADMINISTRATIVE SYSTEMS (3) Urban areas as administrative and policy systems; urban responses to problems of policy planning and implementation; approaches to urban analysis. *Lee, McDavid, and Poister*
 579. METHODS OF ANALYSIS AND MEASUREMENT IN PUBLIC ADMINISTRATION (3 per term, maximum of 6) Examination and application of analytical techniques for evaluating organizational performance and program effectiveness in government agencies. *McDavid, Poister, and Stipak*
 580. INTERNSHIP IN PUBLIC ADMINISTRATION (1-6) *Mowitz*
 581. PUBLIC MANAGEMENT INFORMATION SYSTEMS (3) Examination of the role of management information in public organizations; establishment of information requirements for public programs. Prerequisites: Pub.A. 571, 579. *Stevens*

582. **LEGISLATIVE MANAGEMENT AND OVERSIGHT FUNCTIONS (3)** Examination of the role of the legislature in overseeing the executive; emphasis on financial and program analysis techniques and problems. *Mowitz*

583. **ADVANCED PROGRAM ANALYSIS (3)** Advanced research methods and quantitative techniques as applied to needs assessment and program performance evaluation of public programs. Prerequisite: 6 credits of Pub.A. 579 or other similar course work. *Poister*

584. **RESEARCH SEMINAR IN PUBLIC ADMINISTRATION (1-6)** Application of research methods to problems of organization, management, and policy in public agencies; preparation of research project and report. *Mowitz*

597. **SPECIAL TOPICS (1-6)** *Mowitz*

PUBLIC ADMINISTRATION (P ADM)

DANIEL M. POORE, *Chairman of the Public Administration Program*
The Capitol Campus, Middletown, PA 17057
717-948-6050

Degree Conferred: M.P.A.

Graduate Faculty: Senior Members Ferguson, Gilmore, Masters, McDermott, and Skok.

Graduate Faculty: Associate Members Bresler, Chisholm, McKenna, Munzenrider, Poore, Willets, and Woodruff.

This interdisciplinary program is intended to prepare individuals for professional careers as administrators, project directors, or staff analysts in local, state, or federal government, health care organizations, welfare agencies, and other public service organizations. Applicants are expected to present adequate preparation in American government, college algebra, introductory statistics, economics, accounting, computer methods, and the social and behavioral sciences or equivalent experience, or take work not for graduate credit in those areas.

The degree requires a minimum of 45 credits, including 9 credits of faculty-supervised field study in a public agency in the student's field of interest. The 9-credit field-study requirement may be waived for students who have at least three years of full-time professional experience in relevant administrative or staff work prior to graduation.

The 9-credit field-study course extends over three terms (about nine months) at 3 credits per term. It involves about twenty hours per week during two of the terms and about forty hours per week during the summer term. The field study is integrated with the other course work. The location of the Capitol Campus at the state capital of Pennsylvania provides excellent opportunities for field-study experiences in state government agencies, cities and smaller municipalities, county and federal agencies, large hospitals, Penn State's Milton S. Hershey Medical Center, and other professional and public-service organizations.

Full-time graduate work must be started in September, except under special circumstances. The time required to complete the program as a full-time student is normally eighteen months, including the field-study experience in a public agency.

Part-time students may start the program at the beginning of any term. They usually take one 3-credit course each term but may be permitted to take two courses during a term if their past academic performance is very good and their job situation permits. If a part-time student has sufficient professional work experience to waive the 9-credit field-study requirement, the graduate program can be completed in three years or less.

Students with a 3.00 junior-senior average will be considered for admission. Exceptions may be made for applicants with special backgrounds, abilities, and interests, or with professional experience. Applicants are expected to submit their aptitude scores on the Graduate Record Examination, a short essay outlining their career plans, and two letters of reference. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

COURSES*

ADMIN. 500. ADMINISTRATIVE THEORY (3)

ADMIN. 505. PERSONNEL MANAGEMENT (3)

ADMIN. 510. ORGANIZATION BEHAVIOR (3)

ADMIN. 515. LABOR MANAGEMENT RELATIONS (3)

ADMIN. 520. ADMINISTRATIVE MODELS (3)

ADMIN. 552. STATISTICAL RESEARCH METHODS (3)

P.ADM. 391G. QUANTITATIVE METHODS REVIEW FOR PUBLIC ADMINISTRATION (2) An accelerated review of selected techniques from algebra and finite mathematics applied to public management problems.

P.ADM. 393G. INTRODUCTORY GOVERNMENTAL AND NOT-FOR-PROFIT ACCOUNTING (2) Accounting concepts and techniques needed by the public administrator for financial decision making and control.

P.ADM. 440. HEALTH SYSTEMS ORGANIZATION (3) Health care policy issues, economics, planning, institutional/ambulatory care delivery, programs, manpower, technology, systems reform; public sector emphasis. Prerequisites: So.Sc. 301, 350.

P.ADM. 500. PUBLIC ORGANIZATION AND MANAGEMENT (3) Development of public administration; administrative theory and practice in public organizations. Prerequisites: 3 credits of American government, 6 credits of behavioral science, and 3 credits of micro/macro economics.

P.ADM. 501. ADMINISTRATION AND THE POLITICAL PROCESS (3) Analysis of the relationship of administration to the political processes that shape public policy formulation and execution. Prerequisites: 3 credits of American government and 3 credits of micro/macro economics.

P.ADM. 502. GOVERNMENTAL FISCAL DECISION MAKING (3) Nature, function, and technique of governmental budgeting viewed as mechanism for allocating resources among alternative public uses. Prerequisites: P.Adm. 500, 501.

P.ADM. 503. (†R.PL. 500) RESEARCH METHODS (1-3) Examination of research methodologies relevant to administration, planning, and public policy. Prerequisite: 3 credits in statistics.

P.ADM. 504. LEGAL AND SOCIAL CONTEXT OF PUBLIC ADMINISTRATION (3) The legal framework for public administration, the administration of public law, conduct of legal research, and socio-legal issues. Prerequisite: 3 credits in American government.

P.ADM. 520. QUANTITATIVE MODELS FOR PUBLIC ADMINISTRATORS (3) Applications of quantitative models for the administrator's viewpoint. Explanation of the underlying models, assumptions made, questions explored, without mathematical detail. Prerequisites: P.Adm. 502, 503.

P.ADM. 522. GOVERNMENT FINANCIAL MANAGEMENT (3) Theories and techniques of financial planning and control with emphasis on their application in government and nonprofit agencies. Prerequisites: P.Adm. 502 and 3 credits of accounting.

P.ADM. 524. ADMINISTRATIVE LAW (3) Statutory and judicial controls upon administrative discretion. Administration of rule making, rate setting, licensing, adjudication. Judicial review and citizen advocacy. Prerequisites: P.Adm. 500, 501, 502.

P.ADM. 530. FIELD STUDY IN PUBLIC ADMINISTRATION (1-3 per term, maximum of 9) Analysis and written reports on current problems/projects for a public agency in student's concentration area. Readings in concentration area. Prerequisite: permission of program chairman.

P.ADM. 532. URBAN GOVERNMENT (3) Administrative processes and policy problems associated with managing urban communities; political, intergovernmental, fiscal, structural, and analytical concepts in urban government.

*Descriptions of courses with Admin. designations can be found under that field of study.

†Offered at Capitol Campus only.

P.ADM. 540. ADMINISTRATIVE POLICY FORMULATION (3) Analysis of administrative problems from a total organization viewpoint. Case studies of actual organizations are used for analysis.

P.ADM. 541. HEALTH ECONOMICS AND POLICY (3) Public policy issues, health system components from economic perspective. Economic analysis of health sector, medical markets, health care regulation. Prerequisites: P.Adm. 400 and introductory economics.

P.ADM. 545. HEALTH FINANCIAL MANAGEMENT (3) Theory and techniques of financial management applied to health organizations; forecasting, control systems, working capital, capital budgeting, and institutional financing. Prerequisites: P.Adm. 400, 541, and elementary accounting.

P.ADM. 546. HEALTH PLANNING FOR PUBLIC ADMINISTRATION (3) Comprehensive planning and program planning for health services, facilities, and manpower; social, economic, and political considerations; methodological problems. Prerequisites: P.Adm. 503, 541.

P.ADM. 550. PROGRAM PLANNING AND EVALUATION (3) Analysis and evaluation of public programs and systems from the perspectives of policy development and administrative planning and management. Prerequisites: P.Adm. 502, 503.

P.ADM. 554. MASTER'S PROJECT (1-3) Student independently executes an applied professional or research project, involving the analysis of a management or a public policy problem. Prerequisite: P.Adm. 503.

P.ADM. 556. STATE GOVERNMENT ADMINISTRATION (3) Study of structures, systems, processes, problems, and issues affecting state government administration; case studies, field observations, and research. Prerequisite: P.Adm. 500, 501.

P.ADM. 557. FEDERALISM AND INTERGOVERNMENTAL RELATIONS (3) Study of the impact of a federal system of government on the administration of public functions. National-state-local dimensions. Prerequisite: P.Adm. 500, 501.

P.ADM. 558. LEGISLATIVE PROCESSES (3) Legislatures in American government emphasizing comparative state legislatures: constitutional patterns; organization, administration; interaction with bureaucracy, constituencies, and organized interests. Prerequisite: P.Adm. 500, 501.

P.ADM. 590. COLLOQUIUM (1-3)

P.ADM. 596. INDIVIDUAL STUDIES (1-6)

P.ADM. 597. SPECIAL TOPICS (1-6)

RECREATION AND PARKS (RC PK)

KARL G. STOEDFALKE, *Associate Dean for Academic Affairs*
274 Recreation Building
814-865-0407

Degrees Conferred: M.S., M.Ed.

Graduate Faculty: Senior Members Lundegren, Godbey, and Stoeðfálke.

Graduate Faculty: Associate Members Chase, Christiansen, Elliott, Farrell, Guadagnolo, and Kennedy.

The graduate program is designed to prepare students for administrative, supervisory, research, and teaching positions in public recreation and park systems, in colleges and universities, in voluntary agencies, and in institutions.

The program is oriented to meet the specific needs and research interests of the candidate. Students may pursue interests in the community, including public park and recreation systems, quasi-public and voluntary agencies, and private enterprises; institution and community-oriented therapeutic settings concerned with many different disabilities and utilizing a variety of activity modalities; and camping and outing activities, park planning, interpretive services, outdoor education, and outdoor recreation services.

The master's degree may be earned in the major program of recreation and parks. At the doctoral level, the Ph.D. and D.Ed. may be earned with a specialization in recreation and parks within the physical education major. Detailed information is available from the department.

For admission to the graduate program, a bachelor's or master's degree is required, preferably in recreation and parks. Candidates from other majors are welcome to apply; however, additional course work is required. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

RECREATION AND PARKS (RC PK)

421. WATER-ORIENTED OUTDOOR RECREATION (3)
425. INTERPRETIVE SERVICES (3)
429. INTERPRETIVE PLANNING (2)
430. OUTDOOR EDUCATION METHODS AND MATERIALS (3)
433. EVALUATION IN RECREATION AND PARKS (3)
434. FUNCTIONAL PLANNING AND EVALUATION OF PARK SUPPORT SYSTEMS (3)
435. RECREATION FACILITY PLANNING (3)
440. ADMINISTRATION OF ENVIRONMENTAL PROGRAM OPERATIONS (3)
450. RECREATION ISSUES (1)
458. DYNAMICS OF RECREATION GROUPS (3)
460. LEGAL ASPECTS OF RECREATION AND PARKS (3)
462. (Soc. 462) THE SOCIOLOGY OF LEISURE (3)
465. ADMINISTRATION OF RECREATION AND PARKS (3)
470. PARK MANAGEMENT (3)
477. THERAPEUTIC RECREATION SERVICES (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. (Ph.Ed. 500) INDIVIDUAL STUDY AND RESEARCH PROJECTS (1-10) Prerequisite: Rc.Pk. 530.
515. PROGRAM DEVELOPMENT AND SUPERVISION (3) Critical analysis of the individual, political, and societal determinants of recreation programming; demonstration projects; evaluative procedures, research functions in programming. Prerequisite: Rc.Pk. 456.
520. SEMINAR IN ENVIRONMENTAL EDUCATION ADMINISTRATIVE PROBLEMS (3) Focus upon use of the outdoors by special groups in resident and nonresident settings. Prerequisite: Rc.Pk. 230 or 430.
522. SEMINAR IN CURRICULUM, SUPERVISION AND EVALUATION OF ENVIRONMENTAL EDUCATION PROGRAMS (3) Prerequisite: Rc.Pk. 430.
525. BEHAVIORAL PATTERNS OF THE OUTDOOR RECREATIONIST (3) Patterns of time and space use; user characteristics; meaning of participation; facilitation of environment-use enhancement. Prerequisite: Rc.Pk. 420.
530. (Hl.Ed. 530, Ph.Ed. 530) RESEARCH TECHNIQUES IN HEALTH AND PHYSICAL EDUCATION AND RECREATION (3) Research techniques, including methods, research design, techniques for data collection, as applied to relevant problems in the health education field.
533. RECREATION STUDIES, SURVEYS, AND APPRAISALS (3) Advanced research procedures related to special recreation and park problems. Prerequisites: Rc.Pk. 530 and 3 credits in statistics.
540. PUBLIC AND PRIVATE RECREATION LANDS AND WATERS (3) Public and private roles and interactions, allocation of resources, use policies, open space concepts, private enterprise developments, legal controls.
542. ENVIRONMENTAL LAW (3) Legislative, judiciary, administrative processes-roles; citizen action; legal concepts, litigation and enforcement tactics for protection and enhancement of natural environment.
550. SEMINAR IN RECREATION AND PARKS (1-6)

560. **ADMINISTRATIVE PROBLEMS OF RECREATION AND PARKS (3)** Special problems of recreation and park departments; legal powers and liability; departmental organization, financing, personnel policies, and staff development. Prerequisite: Rc.Pk. 465.

570. **CONCEPTUAL BASES FOR THERAPEUTIC RECREATION (3)** Issues in the application of concepts in therapeutic recreation from a multidisciplinary perspective; evaluation and research. Prerequisite: Rc.Pk. 477.

590. **COLLOQUIUM (1-3)**

595. **PHILOSOPHICAL AND SOCIAL BASES OF RECREATION (3)** Philosophical and social bases of recreation; analysis of critical issues of recreation for philosophical and social implications.

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

REGIONAL PLANNING (R PL)

HAYS B. GAMBLE, *Chairman of the Graduate Program in Regional Planning*

213 Willard Building

814-865-8333

Degree Conferred: M.R.P.

Graduate Faculty: Senior Members J. Coyle, Gamble, Larson, Lee, J. Miller, Newman, and Young.

Graduate Faculty: Associate Members Erickson, Loukissas, and B. Myers.

The graduate program in regional planning emphasizes a multidisciplinary approach to the planning process for multijurisdictional areas, both urban and rural. The program's basic intent is to develop technically competent regional planners who are aware of the social, political, economic, and physical purposes of planning. A strong feature of the program is that it provides a broad opportunity for a student to pursue a sequence of courses in a special option or to earn a concurrent degree in a planning-related discipline. A nonthesis option is available for the MRP degree. Graduates of the program are employed in planning agencies in all levels of government and in private industry.

For admission a student must have had at least one course in each of the following areas: statistics, economics, ecology, sociology, public administration or political science, and physical geography or cartography. Applicants must submit scores on the Graduate Record Examination with their applications. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered up to the number of spaces available. Exceptions to the 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

REGIONAL PLANNING (R PL)

400. **PRINCIPLES OF REGIONAL PLANNING (3-6)**

410. **PLANNING PROGRAMS (3)**

440. **PROBLEMS IN COMMUNITY AND REGIONAL PLANNING (1-9)**

*500. (P.Adm. 503) **RESEARCH METHODS (1-3)** Examination of research methodologies relevant to administration, planning, and public policy. Prerequisite: 3 credits of statistics.

502. **REGIONAL SYSTEMS ANALYSIS (3-6)** Spatial structure of regional and interregional systems; theories of regional development; spatial measures of location, density, central tendency, and dispersion.

*Offered at Capitol Campus only.

- 503. THEORY AND METHOD OF PLANNING (3) Analysis of normative models of planning processes: social, economic, political, and behavioral assumptions, and methodological problems of evaluatory planning performance.
- 510. PLANNING TECHNIQUES AND ANALYSIS I (3) Regional socioeconomic structure, problems, and factors in planning; data collection, analysis, and implications.
- 520. PLANNING TECHNIQUES AND ANALYSIS II (3) Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.
- 530. PLANNING TECHNIQUES AND ANALYSIS III (3) Effects of political, cultural, and physical factors on planning.
- 531. PLANNING AND THE LAW (3) Sources of legal power, its transfer among governmental units; nature of regulatory power and legal constraints upon planning decision making.
- 540. PROBLEMS IN REGIONAL PLANNING (1-9) Planned individual projects involving library, laboratory (studio), or field work.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

RELIGIOUS STUDIES (RL ST)

YOSHIO FUKUYAMA, *Head of the Department*
 1001 Liberal Arts Tower
 814-865-3403

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Cherry, Fukuyama, Harrison, Harshbarger and Prebish.

Graduate Faculty: Associate Members Buckley, Cohn, Lowrie, Stephens, Van Herik, and Vastyan.

The emphasis of this program is on the comprehensive understanding of the various facets of religion in American culture. A broad cross-disciplinary scope is encouraged in substantive areas with particular emphasis on the development of religious thought and movements and the relationships between religion and society. The student will share responsibility with the faculty in shaping a program.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

Applications will be evaluated on the basis of the quality of undergraduate, graduate, or professional records and on the basis of the candidate's clarity of understanding and interest in the specific emphases of the program. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Graduate Record Examination scores, letters of recommendation, and a statement of the applicant's career goals and academic interests are required.

RELIGIOUS STUDIES (RL ST)

- 401. SEMINAR IN COMPARATIVE RELIGION (3 per term, maximum of 6)
- 402. SEMINAR IN CONTEMPORARY RELIGIOUS THOUGHT (3 per term, maximum of 6)
- 408. HINDUISM (3)
- 409. BUDDHISM (3)
- 411. SEMINAR IN JUDAISM (3 per term, maximum of 6)
- 421. CULTURE AND RELIGIOUS REFORM (3)
- 422. RELIGION AND AMERICAN CULTURE (3 per term, maximum of 6)
- 430. SEMINAR IN RELIGIOUS ETHICS (3)
- 438. (Soc. 438) RELIGION AND URBAN SOCIETY (3)

- 439. (Psy. 439) SACRED AND PROFANE THERAPIES (3)
- 461. (Soc. 461) SOCIOLOGY OF RELIGION (3)
- 479. (Psy. 479) SEMINAR: RELIGION AND CULTURE IN FREUDIAN THOUGHT (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 500. THEORIES OF RELIGION (3-6) Cross-disciplinary study of two or more systematic theories of religion: anthropological, phenomenological, philosophical, psychological, sociological, or theological.
- 502. STUDIES IN COMPARATIVE RELIGIONS (3-6) Cross-cultural comparative studies of two or more world religions.
- 505. SEMINAR IN ASIAN RELIGIONS (3-6) Studies in selected Asian religions.
- 521. ISSUES IN WESTERN RELIGION (3-6) Seminar. Study of selected issues in Western religion.
- 522. ADVANCED STUDIES IN AMERICAN RELIGION (3-6) In-depth inquiry into either a period, a movement, or a topic of American religion.
- 524. MAJOR WESTERN RELIGIOUS THINKERS (3-6) Systematic inquiry into the religious thought of major Western religious thinkers.
- 530. RELIGION AND SOCIETY (3-6) Studies of mutual influences and effects of religion and secular phenomena.
- 532. RELIGION AND SOCIAL PROBLEMS (3-6) Study of a selected social issue, or constellation of issues, with analysis of its religious and normative dimensions.
- 536. RELIGIOUS STRUCTURES AND PROCESSES (3-6) Study of the relationship between religion as social structure and as a dynamic social function.
- 539. ADVANCED STUDIES IN RELIGIOUS ETHICS (3-6) A systematic study of the structure and essential themes of ethics of religious institutions and thinkers.
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)

RURAL SOCIOLOGY (R SOC)

JOHN W. MALONE, JR., *Head of the Department of Agricultural Economics and Rural Sociology*
 6 Weaver Building
 814-865-5461

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Bealer, Brown, Crawford, Malone, Stokes, Warland, Wilkinson, and Willits.

Graduate Faculty: Associate Members Crider, Heasley, Leadley, Moore, and Rodefeld.

All degree programs emphasize a comprehensive understanding of the various facets of societal organization pertinent to the rural sector. While scope is encouraged, areas of special interest and research include: consumer behavior, instigated social change, community structure, leadership, population, rural health, rural community services, the structure of agriculture, and the ecology of rurality in industrialized and urbanized society. All students are required to have training in sociological theory, statistics, and research methods.

There is no foreign language requirement for the Ph.D. degree; the student is expected to substitute such courses and instruction necessary to generate superior capabilities of inquiry into an analysis of basic and/or applied rural sociological problems.

Prerequisites for the master's program include 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If the entering student does not have these prerequisites, they must be made up at the University during the early part of the master's program.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

RURAL SOCIOLOGY (R SOC)

- 402. CONSUMER BEHAVIOR AND THE AGRICULTURAL INDUSTRY (3) *Herrmann*
- 405. LEADERSHIP FOR SOCIAL CHANGE (3) *Heasley*
- 425. POVERTY ANALYSIS: PEOPLE AND PROGRAMS (3) *Van Horn*
- 444. THE RURAL TRANSITION IN AMERICAN SOCIETY (3) *Leadley*
- 452. RURAL ORGANIZATION (3) *Wilkinson*
- 456. RURAL COMMUNITY SERVICES (3) *Leadley*
- 459. RURAL SOCIAL PSYCHOLOGY (3) *Willits*
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 501. DEVELOPMENT OF RURAL SOCIOLOGY (2) Historical development with emphasis on American rural sociology. Odd years. *Crider*
- 502. ADVANCED RURAL SOCIOLOGY (3) Structure and functioning of rural society; evaluation of theoretical systems. Even years. *Bealer*
- 510. RURAL MIGRATION (2) Rural migration research and theory; application to governmental and community problems. Odd years. *Stokes*
- 513. SOCIOLOGY OF CONSUMER BEHAVIOR (2) Sociological theory and research pertaining to consumer behavior. Odd years. *Warland*
- 514. VALUES IN RURAL SOCIETY (2) Values as dynamic forces in rural society. Odd years. *Bealer*
- 515. (EXT. ED. 515) THE COOPERATIVE EXTENSION ORGANIZATION (3) The Cooperative Extension Service as a social system, with emphasis on techniques of organization and program development. Prerequisite: 9 credits in education, communication, and/or social sciences. *Thomson*
- 516. CHANGE IN RURAL SOCIETY (2) Social change in rural society, emphasizing prediction and control of the change process. Even years, *Wilkinson*; odd years, *Crider*
- 551. RURAL SOCIOLOGY SEMINAR (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.
- 596. INDIVIDUAL STUDIES (1-6)

SCHOOL PSYCHOLOGY (S PSY)

JOSEPH L. FRENCH, *Chairman of the Committee on School Psychology*
 104 CEDAR Building
 814-865-1881

Degrees Conferred: D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members DiVesta, French, Gorlow, Horan, Keat, Salvia, Weener, and Withall.

Graduate Faculty: Associate Members Berlin, Craighead, Hale, and Snyder.

This intercollege program is based primarily on courses in counselor education, educational psychology, psychology, and special education. In addition, courses are often drawn from individual and fam-

ii) studies, cultural foundations of education, educational administration, and curriculum and instruction.

The objective is to develop a psychologist who is interested in and knowledgeable about education and psychology in the school setting. The school psychologist must utilize professional skill and knowledge about children and youth to make contributions which are meaningful to, and utilized by, teachers, other school personnel, and parents. The development of competences needed by a fully qualified school psychologist requires at least the education represented by a doctoral degree. Only those students who anticipate a doctoral degree will be admitted. Exceptions may be made for students with special backgrounds, abilities, and interests. Students are selected within the limitations of program facilities. Priority is given to applicants with work experience with children.

An undergraduate major emphasizing work in psychology and/or education is preferred, but students with fewer than 15 upper-division credits in psychology, educational psychology, or special education may be admitted with limited deficiencies to be fulfilled concurrently with their graduate work. Requirements for admission include a minimum junior-senior scholastic average of 2.85 or, for applicants with master's degrees, a minimum of one-third of graduate credits of A quality; satisfactory recommendations from two or more professors, preferably psychologists; and 500 or higher on the general sections of the Graduate Record Examination, 58 or higher on the Miller Analogies Test, and/or 35 or higher on the Quantitative Evaluative Device.

Practicum facilities, in addition to those in nearby public schools, include the Center for Educational Diagnosis and Remediation, the School Psychology Clinic, the Speech Pathology and Audiology Clinic, the Reading Center, the Psychology Clinic, and the Campus Demonstration School for handicapped children. Facilities for work with children are also available through other academic units, as well as through assistantship assignments.

The program has been accredited by the American Psychological Association, The National Commission for Accreditation in Teacher Education, and the Pennsylvania Department of Education. Students completing the School Psychology Core Program will have courses in the biological bases of behavior, the cognitive-affective bases of behavior, the social bases of behavior, personality theory, abnormal psychology, human development, professional ethics and standards, research design and methodology, statistics, psychometrics, counseling theory, educational foundations, educational administration, the education of exceptional children, and curriculum. Following the comprehensive examination, an internship is required.

SCHOOL PSYCHOLOGY (S PSY)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

500. PROFESSIONAL ISSUES IN SCHOOL PSYCHOLOGY (1-3) Orientation to the field through study of unique problems, current issues, ethical and legal matters, unique cases, and research projects.

504. PRACTICUM IN SCHOOL PSYCHOLOGY (1-6) Clinical experience with children under supervision in a variety of settings requiring service, including practice in synthesizing data and observations.

508. INTERNSHIP IN SCHOOL PSYCHOLOGY (1-10) Long-term placement in settings providing work for school psychologists with children, parents, teachers, administrators, and service agencies, under supervision.

510. SUPERVISION OF SCHOOL PSYCHOLOGISTS (1-10) Program supervision and professional leadership in university clinics and school systems. Prerequisite: S.Psy. 504.

559. (Psy. 559) THE INDIVIDUAL PSYCHOLOGICAL EXAMINATION (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

596. INDIVIDUAL STUDIES (1-6)

SLAVIC LANGUAGES AND LITERATURES (S L L)

WILLIAM R. SCHMALSTIEG, *Head of the Department of Slavic Languages*
N-440 Burrowes Building
814-865-1352

Degree Conferred: M.A.

Graduate Faculty: Senior Members Birkenmayer, Magner, Paternost, and Schmalstieg.

Graduate Faculty: Associate Members Gebhard and Ivanits.

Opportunities for specialization in literature or linguistics are available. A minimum requirement for admission is an undergraduate major in Russian or its equivalent.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The department prefers that M.A. candidates in this major submit a term paper rather than a thesis.

RUSSIAN (RUS)

- 426. DOSTOEVSKY (3)
- 427. TOLSTOY (3)
- 430. METHODS AND MATERIALS FOR TEACHING RUSSIAN (3)
- 450. HISTORY OF THE RUSSIAN LANGUAGE (3)
- 460. LINGUISTIC ANALYSIS OF CONTEMPORARY RUSSIAN (3)
- 495. PROBLEMS IN RUSSIAN (3-9)

*1G. TECHNICAL RUSSIAN FOR GRADUATE STUDENTS (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

*2G. RUSSIAN TEXTS (3) Development of skill in translating Russian texts in the sciences and social sciences. Prerequisites: Rus. 5 or 1G.

501. READINGS IN RUSSIAN LITERATURE (3-6) Prerequisite: Rus. 204.

525. PUSHKIN (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

540. EIGHTEENTH-CENTURY RUSSIAN LITERATURE (3) Study of the major writers and literary developments in this period of the secularization and modernization of Russian literature.

542. SEMINAR IN SOVIET LITERATURE (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.

570. OLD RUSSIAN LITERATURE (3) Analysis of Russian literary monuments in the original, 1100-1700. Prerequisite: Slav. 550.

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

SLAVIC (SLAV)

500. BIBLIOGRAPHY AND RESEARCH TECHNIQUES (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literatures.

510. STRUCTURE OF THE SOUTH SLAVIC AND WEST SLAVIC LANGUAGES (3-12; 3 credits per language) Linguistic analysis of a particular South Slavic (Bulgarian, Macedonian, Serbo-Croatian, Slovenian) or West Slavic (Czech, Lusatian, Polish, Slovak) language. Prerequisite: Rus. 460 or one graduate course in linguistics.

*No graduate credit is given for this course.

550. OLD CHURCH SLAVIC (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

SOCIOLOGY (SOC)

ROLAND J. PELLEGRIN, *Head of the Department*
201B Liberal Arts Tower
814-865-0172

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Buck, Clemente, DeJong, Faulkner, Pellegrin, Snyder, Steffensmeier, Theodorson, and Westby.

Graduate Faculty: Associate Members Austin, Bord, Clogg, Gelman, Humphrey, Johnson, Mitchell, Sim, Taylor, and Walsh.

The M.A. and Ph.D. programs center on training in basic social theory and methodology and the empirical findings in the various areas of sociology. Departmental offerings cover a wide range, including courses and seminars in most fields of specialization in the discipline. The program is designed with considerable flexibility so that students can adapt course work outside the department to their individual interests and goals. One foreign language and work in computer science, philosophy of science, or mathematics may be used to fulfill the Ph.D. degree communication and foreign language requirement. All first-year students who intend to pursue doctoral work are expected to earn an M.A. degree in their normal progress to the Ph.D. The department offers two options leading to the M.A. For the M.A. preparatory to the Ph.D., students must write a thesis and pass qualifying examinations. For the terminal M.A., students must submit a professional paper approved by a committee of three faculty members.

Undergraduate training in sociology is expected. Students of ability who are deficient in undergraduate preparation may be accepted with provisions to make up course deficiencies in the early part of their graduate program. Candidate selection is based on the following information: quality undergraduate academic performance, above-average Graduate Record Examination scores, letters of recommendation, an essay giving the applicant's interests, goals, and purposes for graduate work in sociology, and submission of written work from the student's undergraduate program, such as a term paper. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

The population issues program is a course of study focusing on the social, economic, and geographic policy-related issues arising from the dynamics of population trends, especially in developed nations. In addition to departmental admission requirements, the population issues committee evaluates the student's interest and aptitude for the training program, which consists of a minimum of 21 credits of interdisciplinary course work in population.

Other areas of study related to sociology, such as rural sociology, community development, cultural anthropology, developmental psychology, and political behavior, are offered in other departments of the University.

Special department-related research and training facilities include the Liberal Arts Data Laboratory, small groups research laboratory, and the Population Issues Research Center. Additional University facilities used by sociology faculty and graduate students include the Computation Center, the Inter-University Consortium of Political and Social Research, the Institute for Policy Research Evaluation, and the Gerontology Center.

SOCIOLOGY (SOC)

400. ADVANCED GENERAL SOCIOLOGY (3)

401. SOCIAL INSTITUTIONS (3)

402. MAJOR ISSUES IN CONTEMPORARY SOCIOLOGICAL THEORY (3)
403. ADVANCED SOCIAL PSYCHOLOGY (3)
404. SMALL GROUPS (3)
406. SOCIOLOGICAL ANALYSIS OF DEVIANCE (3)
408. SOCIAL ECOLOGY (3)
410. SOCIAL PSYCHOLOGY OF HEALTH (3)
412. CRIME AND SOCIAL CONTROL (3)
413. METHODS AND TECHNIQUES OF SOCIAL RESEARCH (3)
415. THE URBAN COMMUNITY (3)
416. (C.F.Ed. 416) SOCIOLOGY OF EDUCATION (3)
419. RACE RELATIONS (3)
422. HISTORY OF SOCIOLOGICAL THEORY (3)
423. SOCIAL DEMOGRAPHY (3)
424. SOCIAL CHANGE (3)
429. SOCIAL STRATIFICATION (3)
430. FAMILY IN CROSS-CULTURAL PERSPECTIVE (3)
432. COLLECTIVE BEHAVIOR (3)
435. SOCIAL GERONTOLOGY (3)
436. (Journ. 436) SOCIOLOGY OF OPINION FORMATION (3)
438. (Rl.St. 438) RELIGION AND URBAN SOCIETY (3)
444. COMPLEX ORGANIZATIONS (3)
446. POLITICAL SOCIOLOGY (3)
447. (M.E.R. 447) ENVIRONMENTAL SOCIOLOGY (3)
450. COMMUNITY ORGANIZATION (3)
453. (Anthy. 453) PRIMITIVE RELIGION (3)
454. (L.S. 454) INDUSTRY AND THE COMMUNITY (3)
455. (L.S. 455) THE SOCIOLOGY OF WORK (3)
461. (Rl.St. 461) SOCIOLOGY OF RELIGION (3)
462. (Rc.Pk. 462) THE SOCIOLOGY OF LEISURE (3)
470. INTERMEDIATE SOCIAL STATISTICS (4)
473. METHODS OF DEMOGRAPHIC ANALYSIS (3-6)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
499. FOREIGN STUDY IN SOCIOLOGY (2-6)

500. SEMINAR IN GROUP THEORY (1-3) The group as a unit of social structure and action.
502. THEORIES OF SOCIETY (3) Past and present theories of the overall structure and processes of societal functioning.
503. RESEARCH SEMINAR IN SOCIAL PSYCHOLOGY (3-6) Design and conduct of research in areas of mutual interest in social psychology.
- 504-505. CURRENT SOCIAL THEORY (3 each) Current contributions to social theory; their relations to each other and to the larger theoretical structure.
506. SEMINAR IN SOCIOLOGICAL THEORY (3-9)
507. INTRODUCTION TO GRADUATE STUDY IN SOCIOLOGY (1) Required of all incoming graduate students in sociology.
510. FIELD WORK IN SOCIOLOGY (1-6)
511. READINGS IN THE SOCIOLOGY OF HEALTH (1-6) Independent pursuit of existing knowledge in fields of the student's interest, in reference books, monographs, journals. Bibliography preparation. Prerequisite: Soc. 410.
512. SEMINAR IN DEVIANT BEHAVIOR (2-6) Advanced sociological study of crime, juvenile delinquency, mental disorders, suicide, drug addiction, prostitution, and other social deviation.
- 513-514. SOCIOLOGICAL METHODS (3 each) Critical review of methodological issues; philosophy of science; research designs; analysis and interpretation of findings.

515. SEMINAR IN COMMUNITY STUDIES (3)

523. SEMINAR IN POPULATION THEORY AND POLICY (1-6) Critical review of multidisciplinary population research with an emphasis on its relation to policy issues. Prerequisite: 3 credits in population or human ecology.

525. SEMINAR IN SOCIOLOGY (1-6) Research problems in theoretical and applied sociology.

530. RESEARCH ON MARRIAGE AND THE FAMILY (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.

532-533-534. SOCIAL RELATIONS (3 each) Critical appraisal of major social-psychological problems confronting modern man; emphasis on formulation of fruitful research projects and their evaluation.

535. SEMINAR IN GERONTOLOGY (2-6) A structural-functional analysis of current research dealing with the relationships between institutional structure, age grading, and social behavior.

546. SEMINAR IN POLITICAL SOCIOLOGY (3 per term, maximum of 6) Research and analysis of contemporary issues in political sociology.

551. COMPARATIVE INSTITUTIONS AND SYSTEMS OF STRATIFICATION (3) Critical appraisal of major problems in comparative sociology, including comparative studies of Western, socialist, and Third World countries.

555. INDUSTRIAL SOCIOLOGY (3) Research methods and techniques in industrial sociology; current research, unexplored areas.

572-573. SOCIAL STATISTICS (3 each) Application of parametric and nonparametric statistical methods to sociology; sampling; computer data processing techniques.

574-575. QUANTITATIVE SOCIOLOGY (3 each) Problems and issues in the mathematical and quantitative aspects of sociology.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

SOLID STATE SCIENCE (S S S)

ROBERT E. NEWNHAM, *In Charge of Graduate Programs in Solid State Science*
169 Materials Research Laboratory
814-865-1612

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barsch, Biggers, Cross, Dachtler, Das, Fonash, Henisch, Kline, Knox, Macmillan, Madjid, McKinstry, Mulay, Newnham, D. Roy, R. Roy, Spear, Stubican, Thrower, Tressler, Tsong, Vedam, Walker, and W. White.

Graduate Faculty: Associate Members Ashok, Johnson, Messier, and Schulze.

The aim of this intercollege program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the necessary fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The program of courses taken by a student majoring in this program must necessarily cut across two or more disciplines. The relevant subject matter has been grouped into four areas: (1) the structure of solids (crystal chemistry and structure determination); (2) theory related to the solid state (physics,

chemistry, and mechanics); (3) properties of solids (optical, electrical, magnetic, mechanical, thermal, and chemical); and (4) reactions of solids (phase equilibria, reaction mechanisms, reaction kinetics, and surface reactions).

The course work of all students will normally include the "core program" as periodically redefined. Recommended course sequences for each year for students with different undergraduate backgrounds are prepared by the chairman and are available from the student's adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages, or by one foreign language together with courses from other designated areas.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included in it mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. The applicant should be interested specifically in an interdisciplinary program of study and research. Thesis research on various aspects of the solid state may be conducted in the Materials Research Laboratory, the Applied Research Laboratory, or in appropriate departments in the Colleges of Earth and Mineral Sciences, Engineering, and Science. The experimental facilities for research in several aspects of materials science and engineering are exceptional.

S.S.S. 590 (Colloquium) and S.S.S. 596 (Individual Studies) will be offered once each year to promote the interdisciplinary aspects of solid state science. Further information will be available from the Solid State Science office.

In addition, students may select appropriate course work from any engineering or science department. The following list includes those which are most commonly taken to satisfy core curriculum requirements: Structure of Solids: Mat.Sc. 408, 512, 514. Solid State Chemistry: Mat.Sc. 416, 501, 503. Solid State Physics: Phys. 412, 413, 524, and Cer.Sc. 508.

SOLID STATE SCIENCE (S S S)

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

SPANISH (SPAN)

MARTIN S. STABB, *Head of the Department of Spanish, Italian, and Portuguese*
N-352 Burrowes Building
814-865-4252

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Dalbor, Halsey, Lima, Lyday, Peavler, Pérez, Stabb, Sturcken, and Triolo.

Graduate Faculty: Associate Members Fitz, Weiss, and Zamora.

The minimum requirement for admission will normally be 24 credits of post-intermediate work in Spanish language and literature. The department may waive the requirement of a thesis for M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPANISH (SPAN)

400. ADVANCED GRAMMAR AND COMPOSITION (3)
 404. THE EVOLUTION OF SPANISH (3)
 410. ADVANCED ORAL EXPRESSION AND COMMUNICATION (3)
 412. TRANSLATION (3)
 413. THE TEACHING OF SPANISH (4)
 414. SPANISH PHONOLOGY (3)
 415. SPANISH MORPHOLOGY AND SYNTAX (3)
 426. THE GOLDEN AGE (3)
 427. DRAMA OF THE GOLDEN AGE (3)
 428. THE GOLDEN AGE (3 per term, maximum of 6)
 439. DON QUIJOTE (3)
 459. THE GENERATION OF 1898 (3)
 472. THE CONTEMPORARY SPANISH AMERICAN NOVEL (3)
 475. INTRODUCTION TO LATIN AMERICAN LITERATURE (3)
 476. INTRODUCTION TO LATIN AMERICAN LITERATURE (3)
 478. NATIONAL LITERATURE OF SELECTED HISPANIC COUNTRIES (3-9)
 482. SPANISH LYRIC POETRY (3)
 483. SPANISH DRAMA OF THE NINETEENTH CENTURY (3)
 484. MASTERPIECES OF MODERN SPANISH DRAMA (3 per term, maximum of 6)
 485. SPANISH DRAMA OF THE TWENTIETH CENTURY (3)
 487. THE SPANISH NOVEL OF THE NINETEENTH CENTURY (3)
 488. MASTERPIECES OF THE SPANISH NOVEL (3 per term, maximum of 6)
 489. THE SPANISH NOVEL OF THE TWENTIETH CENTURY (3)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)
 499. FOREIGN STUDY IN SPANISH (3)
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502. THEORY AND TECHNIQUES OF TEACHING SPANISH (1-3) Audio-lingual orientation.
 503. METHODS AND BIBLIOGRAPHY IN SPANISH (1-3) Methods of research; evaluation of sources and materials.
 505. OLD SPANISH: PHONOLOGY, MORPHOLOGY, AND SYNTAX (3) *Sturcken*
 506. HISTORY OF THE SPANISH LANGUAGE (3) *Sturcken*
 507. HISPANO-ROMANCE LINGUISTICS (3) *Sturcken*
 510. SPANISH DESCRIPTIVE LINGUISTICS: PHONOLOGY (3) *Dalbor*
 511. SPANISH TRANSFORMATIONAL-GENERATIVE LINGUISTICS (3) *Dalbor*
 514. HISPANIC DIALECTOLOGY (3) Early fragmentation among the peninsular dialects; origins and descriptive analysis of the American dialects; Judeo-Spanish. *Dalbor and Sturcken*
 516. MEDIEVAL SPANISH LITERATURE (3 per term, maximum of 9) Topics vary: *juglaría* and *clerecía*, emergence of lyric and brief narrative; history and didacticism; origins of novel; balladry; fifteenth-century innovations.
 518. EL LIBRO DE BUEN AMOR (3) *Sturcken*
 521. THE CELESTINA AND THE LITERATURE OF THE SPANISH PRE-RENAISSANCE (3) Chief trends and works of the period of the Catholic monarchs, with special emphasis on Fernando de Rojas' masterpiece *La Celestina*. *Pérez and Triolo*
 526. SIXTEENTH-CENTURY SPANISH LITERATURE (3 per term, maximum of 9) Prose and poetry of major authors: works and trends of the Renaissance and the early Golden Age. *Pérez and Triolo*
 528. SEVENTEENTH-CENTURY SPANISH LITERATURE (3 per term, maximum of 9) Prose and poetry of major authors: works and trends of the late Golden Age and Baroque period. *Pérez and Triolo*

538. THEATRE OF LOPE DE VEGA AND HIS CYCLE (3) Major works of Lope de Vega, Tirso de Molina, Guillén de Castro, Mira de Amescua, and others. *Pérez*
539. THEATRE OF CALDERÓN DE LA BARCA AND HIS CYCLE (3) Major works of Calderón de la Barca, Rojas Zorrilla, Agustín Moreto, and others. *Pérez*
540. CERVANTES (3 per term, maximum of 9) The literary works of Cervantes: Don Quijote, other novels, dramatic works, and poetry. *Pérez*
544. SPANISH ROMANTICISM (3) The major authors and works of peninsular romanticism, including poetry, drama and prose. *Halsey and Lima*
550. SPANISH REALISM (3) The major figures of the period with special emphasis on Pérez Galdós. *Zamora*
554. GENERATION OF 1898: PROSE (3) Selected essays and novels from the works of Gánivet, Pidal, Unamuno, Maeztu, Azorín, Lanza, Baroja and Valle-Inclán. *Lima and Zamora*
555. GENERATION OF 1898: POETRY AND DRAMA (3) Selected poems and plays from the works of Antonio and Manuel Machado, Benavente, Grau, Azorín, Valle-Inclán, Unamuno, Baroja and others. *Lima*
560. THE CONTEMPORARY NOVEL IN SPAIN (3) The novel since 1941: Cela, Laforet, Zunzunegui, Suárez Carreño, Matute, and others. *Zamora*
563. CONTEMPORARY DRAMA IN SPAIN (3) The drama from 1898 to the present day: Benavente, Valle-Inclán, García Lorca, Casona, Buero Vallejo, Sastre, and others. *Halsey and Lima*
566. CONTEMPORARY SPANISH POETRY (3) Various currents in Spanish poetry from the generation of 1927: Lorca, Aleixandre, Salinas, Guillén, Alonso, Alberti, Hernández, Otero and others. *Staff*
568. EARLY SPANISH AMERICAN LITERATURE (3 per term, maximum of 9) Content varies; selected topics from colonial period, romanticism, and the nineteenth century before modernism. *Staff*
570. MODERNISMO (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío. *Staff*
574. THE SPANISH AMERICAN NOVEL (3 per term, maximum of 9) Content varies; selected works from the late nineteenth century through the contemporary period. *Peavler*
575. THE SPANISH AMERICAN ESSAY (3) Tracing the history of ideas in Spanish America through major essayists. *Stabb*
576. TWENTIETH-CENTURY SPANISH AMERICAN POETRY (3) Influential poets and literary movements after *Modernismo*. *Lyday and Stabb*
577. SPANISH AMERICAN DRAMA (3) Dramatic literature in Spanish America from colonial times to the present. *Lyday*
581. THE SPANISH AMERICAN SHORT STORY (3) Critical analysis of the major writers and movements from Echeverría to the present. *Lyday, Peavler, and Stabb*
587. STYLISTIC AND LITERARY CRITICISM (3) Major theories of literary criticism applied to Hispanic literature.
588. SEMINAR IN HISPANIC LITERATURE (3-12) Common and individual research in special problems in Spanish or Spanish American literature.

SPECIAL EDUCATION (SPLED)

G.P. CARTWRIGHT, *In Charge of Graduate Programs in Special Education*
327 CEDAR Building
814-863-2286

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members C. Cartwright, G. Cartwright, French, Moores, Neisworth, Salvia, and Tawney.

Graduate Faculty: Associate Members Gajar and Sindelar.

Exceptional children are those who deviate so far from average in physical, intellectual, emotional, or social characteristics that they cannot profit adequately from the usual public school program. It is the purpose of this program to prepare teachers, researchers, administrators, and college and university teachers in the areas encompassing the education of the mentally retarded, gifted, emotionally disturbed, neurologically impaired, or learning disabled. A multidisciplinary approach is emphasized. The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages.

Prerequisites for a master's program include: 21 credits basic to the education of exceptional children (courses comparable to E.E.C. 400, 401, 403, 454; E.E.C. 410 or 430 or 470; Mth.Ed. 420; a 400-level course in child development or child psychology; and a 400-level course in foundations of education).

Highest admission priorities are given to applicants who possess certification in special education or elementary education. Applicants for master's and doctoral programs must present evidence of superior academic achievement and aptitude, complete a personal statement, present Graduate Record Examination (GRE) verbal and quantitative test scores, or MAT scores, and provide professional references. Minimum test scores of master's and doctoral applicants respectively are: MAT, 35 and 50; GRE (verbal and quantitative combined), 900 and 1100. Applicants for doctoral study must have had at least two years of relevant experience with handicapped children. Applicants from foreign countries must submit TOEFL scores. Exceptions to the admissions criteria may be made only for highly qualified students with special backgrounds, abilities, and interests.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

400. INTRODUCTION TO EXCEPTIONAL CHILDREN (3)
401. EDUCATIONAL ADJUSTMENTS FOR EXCEPTIONAL CHILDREN (3)
403. CLINICAL TEACHING WITH EXCEPTIONAL CHILDREN (3)
405. PRACTICUM IN THE EDUCATION OF EXCEPTIONAL CHILDREN (1-12)
410. THE MENTALLY RETARDED (3)
411. INSTRUCTION FOR THE SEVERELY MENTALLY RETARDED (2)
412. INSTRUCTION FOR MILDLY HANDICAPPED CHILDREN (2)
413. (Vo.Ed. 413v) VOCATIONAL EDUCATION FOR SPECIAL-NEEDS LEARNERS (3)
415. Early Special Education (3)
420. The Mentally Gifted (3)
430. Learning Disabilities (3)
440. (S.P.A. 440) Survey of Speech and Hearing Disorders (3)
454. Diagnosis of Educational Disabilities (3)
460. Education of Visually Handicapped Children (1)
470. The Emotionally Disturbed Children (1)
472. Educational Problems of Alienated Youth (3)
496. Independent Studies (1-12)
497. Special Topics (1-6)
500. SEMINAR IN SPECIAL EDUCATION (1-9) Continuing series of professional seminars designed to provide a forum for discussion of current and classical research concerning exceptional children. Prerequisites: Ed.Psy. 400 and 6 credits in education of exceptional children.

501. ADMINISTRATION AND SUPERVISION OF EDUCATIONAL PROGRAMS FOR EXCEPTIONAL CHILDREN (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisites: E.E.C. 401 and Ed.Adm. 480, or teaching or administrative or supervisory experience.
502. INTERNSHIP IN SPECIAL EDUCATION (2-10) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty. Prerequisite: E.E.C. 405 or teaching experience.
505. PRACTICUM (1-6) Supervised clinical experience on campus in University-managed diagnostic and remedial settings.
506. FIELD EXPERIENCES IN OFF-CAMPUS LABORATORIES (1-10) Supervised off-campus field experiences in selected laboratory settings with exceptional children. Prerequisite: E.E.C. 505.
507. INTERNSHIP IN SPECIAL EDUCATION SUPERVISION (1-6) Internship in day/residential school setting under supervision of field supervisor and University faculty. Prerequisite: E.E.C. 506.
510. PROBLEMS IN THE EDUCATION OF THE MENTALLY RETARDED (2-4) Study of existing curriculums, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience and E.E.C. 410.
520. PROBLEMS IN THE EDUCATION OF THE MENTALLY GIFTED (2-4) Analysis of educational needs of the mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience and E.E.C. 420.
530. PROBLEMS IN THE EDUCATION OF THE LEARNING DISABLED (2-4) Review of the research and theoretical implications in the educational and behavioral management of learning disabled children. Prerequisite: E.E.C. 430.
545. (S.P.A. 545) CEREBRAL PALSY (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multiprofessional habilitative program. Prerequisite: S.P.A. 444.
547. (S.P.A. 547) LANGUAGE DISORDERS IN CHILDREN (2) Nature, etiology, diagnosis, and management of language disorders in children. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.
554. PSYCHOLOGICAL AND EDUCATIONAL EVALUATION OF EXCEPTIONAL CHILDREN (3) Administration and interpretation of individual tests other than the Stanford-Binet, WISC, WAIS. Prerequisite: Psy. 559.
570. PROBLEMS IN THE EDUCATION OF THE EMOTIONALLY DISTURBED (2-4) Prerequisite: E.E.C. 470.
572. SEMINAR IN THE EDUCATION OF ALIENATED GROUPS (2) A study of the alienated and educational issues of coping with problems of social, cultural, and economic deprivation. Prerequisite: E.E.C. 472.
573. PROBLEMS OF RESEARCH WITH ALIENATED GROUPS (2) A seminar to review and design research studies for the education and training of alienated groups. Prerequisites: E.E.C. 472, 572.
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)
602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

SPEECH COMMUNICATION (SPCOM)

ROBERT S. BRUBAKER, *Head of the Department*
212 Sparks Building
814-865-3461

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Benson, Brubaker, Cohen, Gilbert, Gregg, Hauser, Holtzman, Paulson, Phillips, Rosenfield, and White.

Graduate Faculty: Associate Members Barton, Butt, De Boer, Dunham, B. O'Keefe, D. O'Keefe, Pedersen, and Zawadzki.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication, teaching of speech); speech science (voice, diction, phonetics, general semantics); and communicative theory. A thesis is required of all M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies without credit toward the graduate degree. Sp.Com. 400 and 502 are required of all graduate students who do not have their equivalents.

Students with a 3.00 junior-senior average, with scores on the Graduate Record Examination (general), and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPEECH COMMUNICATION (SPCOM)

*115G. ENGLISH AS A SECOND LANGUAGE (3-15) Development of communicative competence using spoken and written English. Intensive (full-time), intermediate, or advanced sections according to diagnostic test results.

- 400. TEACHING OF SPEECH (3)
- 402. SPEECH AND HUMAN BEHAVIOR (3)
- 403. INTERPERSONAL ORAL COMMUNICATION THEORY (3)
- 410. AMERICAN-ENGLISH PHONETICS (3)
- 412. SPEECH CRITICISM (3)
- 413. (Ling. 413) EXPERIMENTAL LINGUISTICS (3)
- 415. RHETORIC OF FILM AND TELEVISION (3)
- 417. DIRECTING FORENSICS (3)
- 419. (Journ. 419) COMPARATIVE BROADCASTING SYSTEMS (3)
- 420. SYSTEMS AND THEORIES OF RHETORIC (3)
- 425. RADIO PROGRAMMING AND PERFORMANCE (3)
- 431. ANATOMY AND PHYSIOLOGY OF THE VOCAL MECHANISMS (3)
- 435. RADIO AND TELEVISION PROGRAMMING (3)
- 437. TELEVISION PROGRAMMING AND PERFORMANCE (3)
- 440. SYSTEMS AND THEORIES OF HUMAN COMMUNICATION (3)
- 450. THEORY AND PRACTICE OF GROUP COMMUNICATION (3-6)
- 455. GENDER ROLES IN COMMUNICATION (3)
- 470. NONVERBAL COMMUNICATION (3-6)
- 475. PERSUASIVE CAMPAIGNS (3)

*No graduate credit is given for this course.

478. CONTEMPORARY AMERICAN POLITICAL RHETORIC (3)
481. (L.A. 481) COMPUTER APPLICATIONS TO COMMUNICATIONS STUDIES (3)
485. ADVANCED ORAL INTERPRETATION OF LITERATURE (3)
487. (Journ. 487) MASS COMMUNICATIONS STUDY ABROAD (1-9)
490. PSYCHOLOGY OF SPEAKING AND LISTENING (3)
491. COMMUNICATION INTERNSHIP (1-9)
494. TEACHING OF ENGLISH AS A SECOND LANGUAGE (3)
495. DEVELOPMENT OF COMMUNICATION BEHAVIOR IN CHILDREN (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
500. SEMINAR IN AMERICAN ORATORY (2-6) History of American oratory with application of critical standards to the work of specific orators.
502. RESEARCH METHODS IN SPEECH (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech communication, clinical speech, or theatre arts.
503. SEMINAR IN CRITICISM (3) Study of philosophies and methods available for the critical analysis of rhetorical transactions. Prerequisite: Sp.Com. 412.
505. HISTORICAL DEVELOPMENT OF SPEECH THEORY AND CRITICISM (2-4) Classical theories of speech making from the earliest beginnings to the fall of the Roman Empire.
506. HISTORICAL DEVELOPMENT OF SPEECH THEORY AND CRITICISM (2-4) Theories of speech making from the Renaissance to the present.
507. CONTEMPORARY RHETORICAL THEORY (2-4) A study of rhetorical theory from 1930 to the present, focusing on semantic, political, sociological, symbolic, and philosophical perspectives. Prerequisites: Sp.Com. 412, 505 and/or 506.
508. SEMINAR IN BRITISH ORATORY (2-4) History of British oratory; application of critical standards to the work of selected orators.
509. PROBLEMS IN RHETORIC AND ORATORY (2-6) Comparative study of selected orators and rhetoricians. Prerequisite: 6 credits in speech communication.
510. PROBLEMS IN SPEECH EDUCATION (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisites: Sp.Com. 502 and 9 additional credits at the 400 or 500 level in speech communication, clinical speech, or theatre arts.
520. SEMINAR IN SPEECH SCIENCE (3-6) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech communication, speech pathology and audiology, or psychology.
522. (S.P.A. 522) SPEECH PERCEPTION (3) Transformation of linguistic units into acoustic speech signals, theories of speech perception, and auditory processing of the speech signal. Prerequisites: Sp.Com. 410, 431, 520.
530. POLITICAL SPEAKING IN THE BROADCAST MEDIA (3) Study and research of the principles of speaking as they are employed for political purposes when utilizing the broadcast media.
540. SEMINAR IN PROBLEMS OF TELEVISION AND RADIO (2-4) Study and research in television and radio as they pertain to programming, production, relation to society, and speech.
550. SEMINAR IN ORAL PERSUASION (2-4) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech communication including Sp.Com. 200.
552. ORAL COMMUNICATION IN INDUSTRY, BUSINESS, AND GOVERNMENT (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communications skills.
554. SEMINAR IN SMALL GROUP COMMUNICATION (2-4) Communication variables in small groups.

Experimental research and innovations in communication in vocational, therapeutic, and educational groups.

555. **SPEECH COMMUNICATION: PROBLEMS AND PRINCIPLES (2-6)** Prevalent theories of speech influence.

575. **RESEARCH PROBLEMS IN SPEECH (1-9)** Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech communication or speech pathology and audiology.

590. **COLLOQUIUM (1-3)**

597. **SPECIAL TOPICS (1-6)**

602. **SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)**

STATISTICS (STAT)

WILLIAM L. HARKNESS, *Head of the Department*
219 Pond Laboratory
814-865-1348

Degrees Conferred: Ph.D., M.S., M.A.

Graduate Faculty: Senior Members Antle, Bartoo, Haight, Harkness, Hettmansperger, Hultquist, Patil, and Ryan.

Graduate Faculty: Associate Members Arnold, Boswell, Clogg, Lynch, and Rosenberger.

Graduate instruction and research opportunities are available in most areas of statistics and probability, including linear models, nonparametric statistics, robustness, statistical computing, analysis of count data, multivariate analysis, experimental design, reliability, stochastic processes and probability (applied and theoretical), distribution theory, statistical ecology, and biometrics.

The opportunity is also available for students to gain practical experience by participating, for academic credit, in the department's consulting and collaborative research program.

For the M.A. degree the candidate must complete 30 course credits, with at least 18 credits (12 in statistics) of 500-level courses; 6 credits of mathematical statistics, Stat. 409 and 410; 3 credits in computer science, Math. 441 or 481; 3 credits in seminars and/or individual studies; and six credits in an approved area. In addition, the M.A. candidate must submit a master's paper. The requirements for the M.S. degree are the same as for the M.A., except that 6 credits of thesis research replace an equal number of course credits, and a thesis is required rather than a master's paper.

The department administers a master's and Ph.D. qualifying examination which all students in the program must take. Students are examined in two areas of their choice from mathematical statistics, applied statistics, and probability. This examination is intended to be taken early in the program and Ph.D. candidacy is contingent on successful completion of the examination.

After admission to candidacy, each Ph.D. candidate is required to pass two comprehensive examinations. One must be in mathematical statistics and the other in an area to be selected by the candidate, subject to the approval of the faculty. There is no foreign language requirement for the Ph.D. in Statistics. Every Ph.D. candidate is required to perform various services in addition to formal course work. If feasible, they all must gain teaching experience, be involved in statistical consulting (here at Penn State with other graduate students or non-Statistics faculty), and carry out research for the Ph.D. degree.

While applications from all students (including those who already have done graduate work) are reviewed, completion of a standard calculus sequence is regarded as a prerequisite. Students with a 3.00 or better junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

The department requires the verbal and quantitative scores on the Graduate Record Examination from those applicants who wish to be considered for financial support. The Graduate School requires all applicants for admission to submit the GRE scores.

Entering graduate students in Statistics for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. The results of this examination must be received by the Department of Statistics at least six months prior to the requested date of admission to the Graduate School.

Students in the Statistics program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 239).

STATISTICS (STAT)

401. EXPERIMENTAL METHODS I (3)
402. EXPERIMENTAL METHODS II (3)
409. (Math. 409) INTRODUCTION TO PROBABILITY THEORY (3)
410. (Math. 410) MATHEMATICAL STATISTICS I (3)
412. (Math. 412) MATHEMATICAL STATISTICS II (3)
418. (A.M. 418, Math. 418) DISCRETE PROBABILITY THEORY (3)
427. (Math. 427) DISCRETE STOCHASTIC MODELS (3)
451. INTRODUCTION TO APPLIED STATISTICS (3)
460. INTERMEDIATE STATISTICAL METHODS (3)
461. SAMPLING METHODS (3)
462. APPLIED REGRESSION ANALYSIS (3)
464. APPLIED NONPARAMETRIC STATISTICS (3)
480. INTRODUCTION TO STATISTICAL PROGRAM PACKAGES (1)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
501. REGRESSION ANALYSIS AND MODELING (3) Use of simple and multiple regression and correlation to analyze research data; dummy variables, step-wise and non-linear regression. Prerequisite: 6 credits in statistics or Stat. 451; matrix algebra.
502. ANALYSIS OF VARIANCE AND DESIGN OF EXPERIMENTS (3) Experimental design and analysis; fixed, mixed, and random effects models; covariance analysis; multiple comparisons; repeated measures; unbalanced data; computer techniques. Prerequisite: 6 credits in statistics.
503. DESIGN OF EXPERIMENTS (3) Design principles, optimality, confounding in: split plot, repeated measures, fractional factorial, response surface and balanced/partially balanced incomplete block designs. Prerequisite: Stat. 502; Stat. 462 or 501.
504. ANALYSIS OF CATEGORICAL DATA (CONTINGENCY TABLES) (3) Classical analysis of multi-factor contingency tables; linear and log-linear models; measures of association; graphical methods. Prerequisites : 6 credits in statistics, matrix algebra.
505. APPLIED MULTIVARIATE STATISTICAL ANALYSIS (3) Analysis of multivariate data; T^2 -tests; partial correlation; discrimination; MANOVA; cluster analysis; regression; growth curves; factor analysis; principal components; canonical correlations. Prerequisite: 6 credits in statistics.
506. SAMPLING THEORY (3) Theory and application of sampling from finite populations. Prerequisite: 6 credits in statistics.
509. DISCRETE STATISTICAL MODELS AND METHODS (3) Systematic study of probability models and statistical methods pertaining to statistical analysis of data consisting of single and multiple counts.
510. APPLIED TIME SERIES ANALYSIS (3) Identification of models for empirical data collected over time. Use of models in forecasting. Prerequisite: Stat. 462 or 501.
512. (A.M. 512) INTRODUCTION TO STOCHASTIC PROCESSES (3) Markov chains, random walk and recurrent events, queuing theory, time- dependent stochastic processes. Prerequisite: Stat. (Math.) 409 or Stat. (A.M., Math.) 418.

513. (A.M. 513) INTRODUCTION TO STOCHASTIC PROCESSES (3) Markov chains, random walks and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. (A.M.) 512.
- 517-518. (Math. 517-518) PROBABILITY THEORY (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.
524. ECOMETRICS (3) Stochastic models and statistical methods in ecological problems; population dynamics, spatial patterns in populations of one, two, or more species. Prerequisite: Stat. 409 or 418.
534. (M.E.R. 534) DYNAMIC PROGRAMMING (3) The study of the concepts underlying model-building and optimization of dynamic systems; applications to engineering, economic and environmental systems. Prerequisites: Stat. 418; I.E. 405 or Q.B.A. 451.
542. (Math. 542) STATISTICAL DISTRIBUTION THEORY IN SCIENTIFIC WORK: I. DISCRETE MODELS (3) Statistical distributions arising in scientific modeling and statistical inference; structures, interrelations, characterizations, and simulation with practical examples. Prerequisite: Stat. (Math.) 410; knowledge of matrix algebra.
543. (Math. 543) STATISTICAL DISTRIBUTION THEORY IN SCIENTIFIC WORK: II. CONTINUOUS MODELS (3) Statistical distributions arising in scientific modeling and statistical inference; structures, interrelations, characterizations, and simulation with practical examples. Prerequisite: Stat. (Math.) 542.
551. LINEAR MODELS I (3) Statistical distribution theory of quadratic forms and linear transformations; full-rank estimation; regression; response surfaces; Cochran's theorem. Prerequisites: Stat. 502; Math. 441 or 481.
552. LINEAR MODELS II (3) Non-full-rank statistical inference, interaction, variance components, covariance analysis, cross, hierarchal and incomplete classification theory and methodology. Prerequisite: Stat. 551.
561. STATISTICAL INFERENCE I (3) Multiparameter estimation; linear estimation; maximum likelihood estimation; Bayesian estimation; large sample properties and procedures. Prerequisite: Stat. 410.
562. STATISTICAL INFERENCE II (3) Testing statistical composite hypotheses; invariance principles; Bayesian statistics; large sample properties and procedures. Prerequisite: Stat. 561.
564. NONPARAMETRIC STATISTICS: THEORY (3) Estimation and testing based on nonparametric procedures for location and regression models. Distribution theory and asymptotic efficiency. Prerequisites: Stat. 410 and 3 additional credits in statistics.
565. THEORY OF MULTIVARIATE STATISTICAL ANALYSIS (3) Multivariate normal, Wishart and related distribution; Hotelling's T^2 and Cochran's theorem; classification; growth curves; cluster analysis; factor analysis. Prerequisite or concurrent: Stat. 505. Prerequisites: Stat. 410; Math. 441 or 481.
572. STATISTICAL DECISION THEORY I (3) Structure of statistical games; optimal strategies, fixed sample-size games. Prerequisite: Stat. 410.
580. STATISTICAL CONSULTING PRACTICUM (2 per term, maximum of 10) General principles of statistical consulting and statistical consulting experience. Preparation of reports and other aspects of consulting. Prerequisites: Stat. 462 or 501; Stat. 502; Stat. 503 or 504 or 505.
590. COLLOQUIUM (1-3)
596. INDIVIDUAL STUDIES (1-6)
597. SPECIAL TOPICS (1-6)

TEACHING AND CURRICULUM (T & C)

ROBERT LESNIAK, *In Charge of the Graduate Program in Teaching and Curriculum*
The Capitol Campus, Middletown, PA 17057
717-948-6213

Degree Conferred: M.Ed.

Graduate Faculty: Senior Members Allison, Lear, and Swetz.

Graduate Faculty: Associate Members Alexander, Ammon, Barnes, Chant, Eisenstein, Grella, Haber, Lesniak, Miller, Smith, Susskind, and Towns.

The Master of Education in Teaching and Curriculum at Capitol Campus provides to full-time and part-time students a curriculum designed to develop master teachers for public and private school instruction and to develop education specialists (teaching certification not required) for the areas of business, industry, government, medicine, and other social services. In addition, specialties are available in particular areas, such as: reading, urban education curriculum, early childhood education, elementary education and secondary English, social studies, and mathematics education.

Specifically, the goals of the program are to develop in students (1) the ability to communicate effectively either with school-aged students and their parents or with co-workers and/or clients; (2) the ability to conduct an instructional program which provides a sound intellectual and emotional climate for learning; (3) competence in a variety of teaching methods and in the utilization of materials and content appropriate for an effective instructional program; (4) the ability to interpret and to evaluate educational literature and research; and (5) the ability to describe and to evaluate major issues and current trends in instructional curriculum practice and development.

Certification programs are also available in the areas of Reading Specialist (K-12) and Private Nursery School Teachers. For graduates of education undergraduate programs, a total of 36 credits of work normally will be required. Graduates of undergraduate programs other than education normally will be expected to complete substantially more work to satisfy the requirements for this degree. Some of this additional work may include undergraduate courses. Program requirements include 3 credits in foundations of education; each student will be expected to complete from one-third to two-thirds of the work in courses other than education courses; and a minimum of 12 credits in 500-level courses must be completed. The last 12 credits in a student's program must be earned at the Capitol Campus. The application and transcript should be sent directly to the Graduate Office, The Capitol Campus, Middletown, PA 17057.

EDUCATION (ED)

505. CURRICULUM FOUNDATIONS (3) Study of the philosophical, cultural, social, and human developmental sources and implications of the school curriculum.

506. CURRICULUM DEVELOPMENT (3) Examination of theory, issues, organization, and local school problems of curriculum development.

520. SEMINAR IN JUNIOR COLLEGE TEACHING (3) The history of the two-year college, responsibilities of the teacher in the college organization, and methods of teaching.

541. THE ROLE OF THE COOPERATING TEACHER (3) A study of the responsibilities of classroom teachers who cooperate with teacher-preparation institutions. Prerequisite: teaching experience.

550. INTERNSHIP IN JUNIOR COLLEGE (3) Teaching humanities courses in a two-year college under a master teacher, who will direct, criticize, and evaluate the intern.

551. PROBLEMS IN TEACHING READING (3) A research-centered course in teaching reading. Prerequisite: Ed. 322, 451, 471, or 472.

552. PROBLEMS IN TEACHING LANGUAGE ARTS (3) A research-centered course in teaching language arts. Prerequisite: Ed. 416 or 452.

553. PROBLEMS IN TEACHING SOCIAL STUDIES (3) A research-centered course in teaching social studies. Prerequisite: Ed. 415 or 453.

554. **PROBLEMS IN TEACHING SCIENCE (3)** A research-centered course in teaching elementary science. Prerequisite: Sc. 454.
555. **PROBLEMS IN TEACHING MATHEMATICS (3)** A research-centered course in teaching mathematics. Prerequisite: Ed. 455.
560. **CLASSROOM MANAGEMENT (3)** Analysis of teaching styles, classroom behavior and interaction, organization and correlation of classroom activities and subject areas. (Requires practical application in an actual teaching situation.)
561. **PSYCHOLOGY OF READING (3)** Examination of the theoretical bases for reading which have direct practical implication for teaching reading. Prerequisites: Ed. 314, 451.
562. **LEARNING PROBLEMS IN A SCHOOL SETTING (3)** Investigation of surface behaviors and sources of stress in schools which hinder learning, and procedures for overcoming problems.
563. **ADVANCED METHODS IN TEACHING READING (3)** Advanced development of diagnostic and instructional techniques for teaching reading, with emphasis on individual and small group instruction. Prerequisite: Ed. 451.
564. **READING CLINIC (3-6)** A practicum course in which students display their competencies in working with children possessing reading problems. Prerequisite: Ed. 421, 422, 423, 561, 562, 563, Ps.Sc. 405, 406.
571. **GREAT TEACHERS (3)** Study of one or more great teachers, e.g., Socrates, Comenius, Locke, Rousseau, Pestalozzi, Herbart, Froebel, Dewey, Kilpatrick.
572. **COMPARATIVE EDUCATION: WORLD PERSPECTIVES (3)** An evaluative comparison of American education with Western and non-Western educational systems.
585. **MASTER'S PRACTICUM (1-6)** The planning, implementation, and evaluation of an educational innovation in a classroom, or related learning activity.
586. **EDUCATIONAL RESEARCH DESIGNS (3)** Identification of research designs appropriate to educational field and laboratory investigations and the development of a master's paper proposal. Prerequisite: 15 credits of graduate study.
587. **MASTER'S PAPER (1-6)** Development of an original master's paper or creative production by the student, supervised by appropriate faculty and judged by a committee. Prerequisite: consent of adviser.
589. **PROBLEMS IN URBAN EDUCATION (4)** Independent study of selected topics related to urban education.
590. **COLLOQUIUM (1-3)**
591. **EDUCATION SEMINAR (1-6)** Seminars in important, and often controversial, topics in education.
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

THEATRE ARTS (THEA)

ROBERT N. CORNISH, *In Charge of Graduate Programs in Theatre Arts*
103 Arts Building
814-865-7586

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Members Allison, L. Manfull, and Walters.

Graduate Faculty: Associate Members Cook, Cornish, Crocken, Duque, Firmin, Gibson, Maddox, H. Manfull, Sabatine, A. Smith, and Stern.

This program emphasizes the study of the theatre with the following major objectives: (1) to help each graduate student attain skills and proficiencies in theatre arts; (2) to provide the training, discipline, and opportunities essential to the development of a professional ability in at least one area of the arts of the theatre; (3) to prepare students for active careers in academic, professional, and/or community theatre in a recognizably competitive job market; and (4) to assist students in acquiring discriminating taste and critical judgment in drama and theatre.

The Master of Arts degree program provides advanced training in the broad field of the theatre arts. It is designed to prepare the candidate for: (1) professional employment as a Theatre Arts teacher on the secondary or junior college level; (2) critical study and research particularly in preparation for the pursuit of a related doctorate or professional degree; and (3) related professional work in industry, business, or the arts. Two areas of study are required: general theatre (history, theory, criticism, dramatic literature, and research) and practical theatre (acting, directing, design, and technical theatre).

Requirements for admission to the M.A. program are:

1. A broad undergraduate preparation in theatre, including three credits each in acting, directing, stagecraft, and theatre history; and six credits of dramatic literature.
2. An undergraduate grade-point average of no less than 2.50 on a 4.00 scale.
3. Twelve credits in related subject areas such as oral interpretation, art, and music.
4. A vita and at least three letters of recommendation should be submitted.

The M.F.A. program is planned to provide a professional emphasis. Specialization in one of the following areas is stressed: acting; directing; management; production (scene design, costuming, lighting or technical direction); or playwriting. A required final project in the area of specialization includes a monograph. The programs require six to nine terms to complete.

Requirements for admission to the M.F.A. program are:

1. Twenty-four credits in theatre arts, including one course each in acting, directing, and theatre crafts. Related courses in the student's area of specialization may be accepted.
2. All students are to submit evidence of ability in their areas of specialization under arrangements to be made with the department. Auditions, prompt books, portfolios, manuscripts, and other appropriate presentations are to be submitted by applicants to the various study programs.
3. A vita and letters of recommendation (at least three) are to be submitted.
4. Personal interviews should be arranged by all students.

All students in the M.A. and M.F.A. programs who are deficient in the required undergraduate courses may be requested to take additional course work in the areas of deficiency without degree credit.

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

All graduate majors are required to participate in University Theatre productions in positions of responsibility.

Theatre facilities are: the Playhouse, a proscenium-thrust theatre; the Pavilion, an arena or three-quarter theatre; theatre production studios for scenic, property, and costume preparation; rehearsal and dance studios; and a film laboratory with screening and editing facilities. Other University performance facilities include Schwab Auditorium, Kern Assembly Room, Music Concert Hall, and the Milton S. Eisenhower Auditorium with a seating capacity of 2,600. On the campus are several FM radio stations and WPSX, the University's educational TV station.

Related courses offered by other departments may be taken. Dramatic literature courses are available: Class. 411; C.Lit. 486, 487, 588; Engl. 438, 444, 445, 478, 488, 548, 549; Fr. 446, 461, 518, 534, 535, 567; Greek 421, 422. Design and technical courses are available in the Departments of Art, Art History, Engineering, Art Education, Architecture, Human Development, and Vocational Industrial Education. Courses in performance areas are available in the Departments of Music, Music Education, Physical Education, and Speech Communication.

THEATRE ARTS (THEA)

400. ADVANCED THEATRE AND FILM PROJECTS (1-6)
401. HISTORY OF ANCIENT AND MEDIEVAL THEATRE (3)

402. HISTORY OF RENAISSANCE AND ORIENTAL THEATRE (3)
403. HISTORY OF MODERN EUROPEAN AND BRITISH THEATRE (3)
405. HISTORY OF AMERICAN THEATRE (3)
409. FUNDAMENTALS OF CREATIVE PERFORMANCE FOR CLASSROOM TEACHERS (3)
410. CREATIVE DRAMATICS WITH CHILDREN (3)
411. PROJECTS IN CREATIVE DRAMATICS (2)
415. CHILDREN'S THEATRE ENSEMBLE (3 per term, maximum of 9)
416. STAGING THEATRE WITH CHILDREN (3)
417. EXPERIMENTAL TECHNIQUES IN CHILDREN'S THEATRE (3)
418. PUPPETRY (3)
420. ADVANCED VOICE AND DICTION FOR THE ACTOR (3 per term, maximum of 6)
421. DIALECTS FOR THE ACTOR (3 per term, maximum of 6)
422. PERFORMANCE FOR THE CAMERA (3)
423. TECHNIQUES AND STYLES OF THEATRE JAZZ DANCE (3 per term, maximum of 6)
424. DANCE FOR THE THEATRE (3)
425. DANCE FOR THE CONTEMPORARY MUSICAL THEATRE (2-6)
426. CHOREOGRAPHY FOR THE THEATRE (3 per term, maximum of 9)
427. THEATRE MAKEUP (2)
428. ADVANCED ACTING PROJECTS (1-9 per term, maximum of 9)
429. THEATRE PERFORMANCE PRACTICUM (1-6)
434. DIRECTING (3)
435. REHEARSAL METHODS FOR THE DIRECTOR (3)
436. CENTRAL STAGING (3)
437. DIRECTING FOR FILM AND TELEVISION (3)
445. ADVANCED PLAYWRITING (3-6)
446. ADVANCED SCREENWRITING (3-6)
450. ADVANCED SCENE DESIGN (3-6)
460. COSTUME DESIGN (3)
461. COSTUME CONSTRUCTION (3)
462. DRAFTING HISTORICAL COSTUMES FOR THE STAGE (3)
474. STAGE LIGHTING (3)
479. STAGE AND PRODUCTION MANAGEMENT (3)
485. SOUND FOR THEATRE PRODUCTION (3)
489. THEATRE PRODUCTION PRACTICUM (1-6 per term, maximum of 12)
490. ADVANCED FILM PRODUCTION (3 per term, maximum of 6)
491. AMERICAN FILMS (3)
492. FOREIGN FILM (3)
494. DOCUMENTARY IN FILM AND TELEVISION (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)
499. ADVANCED FILM PRODUCTION PRACTICUM (1-12 per term, maximum of 12)

500. THEATRE RESEARCH: SOURCES AND PROCEDURE (3) Source materials and techniques as applied to theatre research; the form and content of theses and monographs.
503. THEATRE CRITICISM AND THEORY (3)
505. THEATRE HISTORY (3) Specific aspects of theatre from ancient times to the present.
522. ACTING I (4) Interpretation of theatrical styles: the tradition of tragedy; voice and movement.
523. ACTING II (4) Interpretation of theatrical styles: the tradition of comedy; voice and movement. Prerequisite: Thea. 522.
524. ACTING III (4) Interpretation of theatrical styles: forms of modern realism; voice and movement. Prerequisite: Thea. 523.
525. ACTING AND DIRECTING THEORY (3) The actor and director as related to cultural environment from the Greek theatre through the post-Stanislavskian theorists.

528. **ADVANCED ACTING PROJECTS (3-9)** Advanced performance projects for the second- and third-year M.F.A. actor who has completed all other performance courses.
530. **PLAY INTERPRETATION FOR THE DIRECTOR (3)** Theory and practice in the analysis and implementation of story, style, and form.
531. **SPECIAL FORMS IN DIRECTING (3)** Applied theory and techniques for various genres and periods of drama. Prerequisite: Thea. 530.
533. **PROJECTS IN DIRECTING (1-6 per term)**
535. **EXPERIMENTAL THEATRE (1-3)** Operational research and experimental methods in the preparation, planning, execution, observation, and evaluation of production.
540. **PLAYWRITING (3-6)** Focus on problems in writing the full-length script through seminar, play reading, and individual session.
543. **PROJECTS IN PLAYWRITING (1-9)** Preparation of the script for revision during and rewriting following production of the student's original play. Prerequisite: production approval.
553. **DESIGN AND TECHNICAL PRODUCTION (1-6 per term)** Special projects in design and technical execution of scenery, costumes, lighting, sound, and special effects.
560. **COSTUME DESIGN (1-6)** Design concepts, rendering, and execution of costumes for the stage.
574. **LIGHTING FOR THEATRE PRODUCTION (3)** Design techniques for production in arena, thrust, and proscenium theatre situations.
580. **THEATRE TECHNOLOGY (3)** Design consultation and specification of equipment, systems, and movable structures for new theatres; structures and projection devices for production.
582. **THEATRE ADMINISTRATION (3)** The theatre: organization and management.
583. **PROJECTS IN THEATRE ADMINISTRATION, MANAGEMENT, AND OPERATIONS (1-6)**
585. **THEATRE PLANNING (3)** Processes and problems in planning and designing theatres: performance, audience, and technical requirements.
590. **COLLOQUIUM (1-3)**
591. **SPECIAL PROBLEMS IN FILM AND TV (1-3 per term)**
596. **INDIVIDUAL STUDIES (1-6)**
597. **SPECIAL TOPICS (1-6)**

URBAN AND REGIONAL PLANNING (UR PL)

ROBERT A. SIMKO, *Head of the Program*
The Capitol Campus, Middletown, PA 17057
717-948-6173

Degree Conferred: M.R.P.

Graduate Faculty: Senior Members Ferguson, Hand, and McDermott.

Graduate Faculty: Associate Members Buskirk and Simko.

The objective of this interdisciplinary program is to train professional planners who will be aware of the needs of citizens so that they can develop programs for sound social, political, economic, and cultural advancement through the enlightened management of all resources. The nonthesis option is available for this program. Course work may be taken at The Capitol Campus or at the Radnor Graduate Center.

For admission a student should have had at least one course each in economics, geography or geology, graphics, and statistics. Students may be admitted with limited deficiencies but are required to remove the deficiencies early in the program without graduate degree credit. Applicants should submit scores on the Graduate Record Examination with their application. Students with a 3.00 junior-senior

average and with appropriate course backgrounds will be considered up to the number of spaces available. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

REGIONAL PLANNING (R PL)

400-401. PRINCIPLES OF REGIONAL PLANNING (3-6)

410. PLANNING PROGRAMS (3)

440. PROBLEMS IN COMMUNITY AND REGIONAL PLANNING (1-9)

*500. (P.Adm. 503) RESEARCH METHODS (1-3 per term) Examination of research methodologies relevant to administration, planning and public policy. Prerequisite: 3 credits in statistics.

501. APPLIED METHODOLOGIES IN REGIONAL PLANNING (3) Selected methodologies used in planning, including: demographic projections, simulations, network analyses, threshold analyses, allocation and location models. Prerequisite: R.Pl. 500.

502. REGIONAL SYSTEMS ANALYSIS (3-6) Spatial structure of regional and interregional systems. Theories of regional development. Spatial measures of location, density, central tendency and dispersion.

510. PLANNING TECHNIQUES AND ANALYSIS I (3) Regional socioeconomic structure, problems, and factors in planning; data collection, analysis, and implications.

520. PLANNING TECHNIQUES AND ANALYSIS II (3) Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.

530. PLANNING TECHNIQUES AND ANALYSIS III (3) Effects of political, cultural, and physical factors on planning.

540. PROBLEMS IN REGIONAL PLANNING (1-9) Planned individual projects involving library, laboratory (studio), or field work.

587. MASTER'S PROJECT (1-6) An original scholarly master's project initiated by the student, supervised by an appropriate professor, and judged by a committee.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

VETERINARY SCIENCE (V SC)

C. S. CARD, *Head of the Department*
115 Animal Industries Building
814-865-7696

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Card, Eberhart, Gentry, Massaro, Rothenbacher, Scholz, and Zarkower.

Graduate Faculty: Associate Members Ferguson, Griel, Harkness, Patton, and Swope.

Graduate programs may be initiated with faculty specializing in areas of veterinary pathology, toxicology, physiology, microbiology, and immunology. A thesis is required of candidates for both the M.S. and Ph.D. degrees.

*Offered only at Capitol Campus.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one of several options including proficiency in reading a foreign language. Foreign students must show competence in English.

Prerequisite for admission is a bachelor's degree in an area of the life sciences or a degree in veterinary medicine. Adequate preparation in the basic sciences is required. Applicants with a 3.00 or better grade-point average and appropriate course backgrounds will be considered. Application for fall term admission must be completed by March 1 and must include GRE scores for the Aptitude Test and Advanced Biology Test.

VETERINARY SCIENCE (V SC)

- 405. LABORATORY ANIMAL SCIENCE (3) *Ferguson*
- 407. DAIRY HERD HEALTH PROGRAMS (2)
- 418. METHODS OF ANIMAL CELL CULTURE (3) *Patton*
- 420. GENERAL ANIMAL PATHOLOGY (3) *Rothenbacher*
- 496. INDEPENDENT STUDIES (1-12)

- 525. MECHANISMS OF HYPERSENSITIVITY AND IMMUNOPATHOLOGY (3) Concepts of hypersensitivity and special consideration of immunopathological conditions. Prerequisites: Biol. 437, Microb. 410, and 3 credits of pathology. *Zarkower and Ferguson*
- 528. DIAGNOSTIC PATHOLOGY (3-9) Gross examination of animals and birds, their tissues and body fluids for pathologic changes. Prerequisites: 6 credits in pathology, microbiology, or infectious diseases. *Card*
- 535. ACQUIRED AND CONGENITAL DISORDERS OF METABOLISM (3) Abnormalities and alterations in metabolism due to dysfunctions of animal organs. Prerequisites: 6 credits in general biochemistry and 3 credits in animal physiology. *Scholz*
- 550. EXPERIMENTAL ANIMAL SURGERY (3) Principles of surgical preparation of experimental animal models for biological research, including aseptic procedures, anesthesia, surgical techniques, and aftercare. Prerequisites: Biol. 42, 421; V.Sc. 405. *Kavanaugh*
- 590. COLLOQUIUM (1-3)
- 596. INDIVIDUAL STUDIES (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

VOCATIONAL EDUCATION (VOCED)

DAVID L. HOWELL, *In Charge of Graduate Programs in Vocational Education*
 111 Armsby Building
 814-863-0443

Degrees Conferred: Ph.D., D.Ed.

Graduate Faculty: Senior Members Brantner, Curtis, Howell, Long, Love, Murray, Ray, Shear, Stinson, Weis, Welch, and Wircenski.

Graduate Faculty: Associate Members Evans, Lindley, Mortensen, Morton, Thal, and Yoder.

This intercollege program emphasizes administration, research, teacher education and supervision, and curriculum development and design across program areas in vocational education.

A minimum of 45 credits is required in the major, to be divided among vocational education, general professional education, and social and behavioral science courses. A minor program of study is required for the D.Ed. degree and is optional for the Ph.D. degree, and may be developed within one of five social and behavioral science options, in general studies, or in other areas approved by the candidate's committee.

The communication and foreign language requirement for the Ph.D. degree may be satisfied from nine options, which include foreign languages, computer science, statistics, technical writing, and philosophic thought.

For admission, students must have a master's degree. Either the master's degree or the bachelor's degree must be in a vocational education specialization, or the applicant must have professional experience in vocational education.

Courses appropriate to these degrees taught in the three participating departments are: Ag.Ed. 418v, 420v, 422v, 424v, 426v, 434v, 501v, 502v, 508v, 509v, 520v, 521v, 524v, 530, 590v, 596v; I.Ed. 402v, 403v, 408v, 409v, 412v, 415v, 420v, 427v, 446v, 450v, 501v, 506v, 510v, 550v, 556v, 557v, 558v, 559v, 560v; H.E.Ed. 406v, 410v, 477v, 478v, 479v, 480v, 481v, 482v, 503v, 504v, 510v, 511v, 518v, 521v, 530v, 577v.

VOCATIONAL EDUCATION (VO ED)

413v. (E.E.C. 413) VOCATIONAL EDUCATION FOR SPECIAL NEEDS LEARNERS (3)

417v. (Cn.Ed. 417) CAREER EDUCATION: ORIGINS, THEORY, IMPLEMENTATION (3)

496v. INDEPENDENT STUDIES (1-12)

497v. SPECIAL TOPICS (1-6)

500v. FOUNDATIONS OF VOCATIONAL EDUCATION (3) Influence of legislative, economic, and social-psychological developments on the status and role of public vocational education in the United States.

508v. ADMINISTRATION OF VOCATIONAL EDUCATION (3) Concepts, strategies in administration of vocational programs in comprehensive high schools, area vocational technical schools, proprietary schools, and colleges.

530v. INTERNSHIP (1-10) Internship at cooperating school, governmental agency, or research institution, under supervision of graduate faculty. Prerequisites: admission to candidacy and completion of 15 credits in residence beyond master's degree.

590v. COLLOQUIUM (1-3)

596v. INDIVIDUAL STUDIES (1-6)

597v. SPECIAL TOPICS (1-6)

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

FREDERICK G. WELCH, *In Charge of Graduate Programs in Vocational Industrial Education*
119 Rackley Building
814-865-8361

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Brantner, Long, Welch, and Wircenski.

Graduate Faculty: Associate Member Passmore.

Emphasis may be placed upon preparation for teaching, supervision, administration, research, or teacher education. The primary focus of the program is preparation for entry into responsible positions within the broadly conceived field of vocational industrial education.

The communication and foreign language requirement for the Ph.D. degree may be met by the successful completion of selected courses in statistics and computer programming.

Persons admitted must have successfully completed a B.S. degree with a 2.50 grade-point average in vocational industrial education or fields related to vocational, safety, or technical education, or health occupations. Two years or more of experience in vocational industrial education, industrial training, military technical training, or work experience in an occupation related to vocational industrial education, vocational education, health occupations, safety education, or technical education are also re-

quired for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

INDUSTRIAL EDUCATION (I ED)

- 402v. SUPERVISION OF VOCATIONAL EDUCATION (3)
- 403v. SUPERVISED FIELD WORK (6)
- 408v. OCCUPATIONS (3)
- 409v. TESTS AND MEASUREMENTS (3)
- 415v. PROBLEMS IN COORDINATING VOCATIONAL EDUCATION (3)
- 427v. ADVANCED COURSE OF STUDY BUILDING (3)
- 446v. IMPROVEMENT OF INSTRUCTION IN VOCATIONAL EDUCATION (4)
- 450v. SHOP LAYOUT AND MANAGEMENT (3)
- 496v. INDEPENDENT STUDIES (1-12)
- 497v. SPECIAL TOPICS (1-6)

501v. SEMINAR IN VOCATIONAL EDUCATION (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. ADMINISTRATION OF VOCATIONAL EDUCATION (3) The job of the local director of industrial education in organizing and developing city and other local programs of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. VOCATIONAL EDUCATION FOR ADMINISTRATORS (3) Designed for school administrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. Iv or trade or teaching experience.

550v. RESEARCH IN VOCATIONAL EDUCATION (3) Research techniques in vocational industrial education.

556v. FEDERAL LEGISLATION (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

557v. PRESENT-DAY LOCAL, PERSONNEL, AND CURRICULUM PROBLEMS (2-3) Various plans, techniques, and practices.

558v. STATE AND LOCAL SUPERVISION AND ADMINISTRATION (2-3) The more important recent problems in organization, supervision, and administration.

559v. VOCATIONAL TECHNICAL EDUCATION (2-3) Problems of organization and administration of programs of technical education at the secondary and post-secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. PHILOSOPHY OF INDUSTRIAL EDUCATION (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

596v. INDIVIDUAL STUDIES (1-6)

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

WILDLIFE MANAGEMENT (W L M)

ROBERT S. BOND, *Director of the School of Forest Resources*
101 Ferguson Building
814-865-7541

Degree Conferred: M.S., M.Agr.

Graduate Faculty: Senior Members George, Hutnik, Lindzey, Storm, and Ward.

Graduate Faculty: Associate Members Kelly, Rader, and Wakeley.

Programs are designed to give students an understanding of the biology and management of wildlife species and their environments, and include training in: wildlife ecology, nutrition, physiology, behavior, and pathology of a wildlife species or species groups; study of successional stages, land use, and management of various habitats and their impact on wildlife populations; population dynamics and manipulation of animal numbers; and studies of recreational, aesthetic, and socioeconomic values of wildlife. Most programs of study are strengthened by including appropriate courses offered by related departments. A thesis is required. The Ph.D. degree in forest resources allows specialization in wildlife ecology and management at the doctoral level (see Forest Resources).

The Master of Agriculture is intended to enable students to develop skills as professionals in the communication of technical knowledge. Candidates will elect a minimum of 15 credits of graduate-level courses in communication skills from courses in departments such as Agricultural Education, Instructional Systems, Journalism, Recreation and Parks, Speech Communication, English, and Theatre. Any deficiencies in a student's resource specialties, as judged by his or her advisory committee, must be remedied. An acceptable paper on a selected professional problem or a report of internship training worth 3 credits or more is also required.

For admission, an applicant should have at least a 2.75 grade-point average, a 3.00 junior-senior average, and should have courses that are basic to the individual's field of specialization. Ordinarily these include 12 credits in communication, 12 credits in social sciences and humanities, 12 credits in quantification including calculus and statistics, 9 credits in physical sciences, 9 credits in biological sciences, and 18 credits in forest products, forestry, wildlife, or related courses. Graduate Record Examination scores and three reference reports (forms supplied on request) and a brief statement describing the applicant's academic goals, career interests, and special qualifications are required. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to admission requirements may be made for students with special backgrounds, abilities, and interests.

WILDLIFE (WIDL)

- 408. MAMMALOGY (3)
- 427. RANGE ECOLOGY AND MANAGEMENT (3)
- 430. WILDLIFE INTERNSHIP (1-6)
- 435. WILDLIFE ECOSYSTEMS (3)
- 446. WILDLIFE ECOLOGY (3)
- 447. WILDLIFE MANAGEMENT (3)
- 492. FIELD RESEARCH TECHNIQUES (3)
- 493. LABORATORY TECHNIQUES IN WILDLIFE RESEARCH (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

- 547. WILDLIFE MANAGEMENT (3) Management, maintenance, and manipulation of wildlife populations and habitat. Prerequisite: Wildl. 447.

- 551. WILDLIFE BIOMETRICS AND POPULATION ANALYSIS (3) Application of biometrics and mathematics to concepts and problems in wildlife ecology with emphasis on population analysis. Prerequisites: 3 credits in animal ecology and 6 credits in biometrics or statistics.

- 590. COLLOQUIUM (1-3)

- 596. INDIVIDUAL STUDIES (1-6)
- 597. SPECIAL TOPICS (1-6)
- 602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2)

ZOOLOGY (ZOO)

E. S. LINDSTROM, *Head of the Department of Biology*
208 Erwin W. Mueller Building
814-865-4562

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cooper, Dunson, Hibbard, Hollis, MacCluer, Wickersham, and Williams.

Graduate Faculty: Associate Members Arnold, Mitchell, Neff, Pearson, Petters, Rheuben, and Turpen.

This program offers emphasis in animal behavior, cell biology, developmental biology, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, morphology, physiology, or population dynamics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Admission is restricted to students who have a baccalaureate degree in a biological science with emphasis on zoological subjects and adequate preparation in mathematics and the physical sciences. A cumulative undergraduate average of at least 3.00 is required. Each applicant must provide scores from the Graduate Record Examination, letters from two persons who are familiar with the student's academic competence, and a personal statement of interests and objectives.

NOTE: *For courses in Zoology and related subjects see Biology, Genetics, and Physiology.*

OTHER GRADUATE COURSES AND OPTIONS

The following courses are interdisciplinary or in fields in which neither graduate major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department head or program chairman, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400-series courses in degree programs apply to these courses.

ADMINISTRATION OF JUSTICE (ADM J)

- 401. PROBATION, PAROLE, AND PARDONS (3)
- 410. CORRECTIONAL COUNSELING PROCESSES (3)
- 420. SPECIAL OFFENDER TYPES (3-6)
- 430. CORRECTIONAL INSTITUTIONS AND SERVICES (3)
- 440. FUNDAMENTAL TECHNIQUES OF SCIENTIFIC CRIMINAL INVESTIGATION (3)
- 441. THE JUVENILE JUSTICE SYSTEM (3)
- 460. HISTORY AND FUNCTION OF CRIMINAL JUSTICE COMPONENTS (3)
- 470. LAW OF CRIMES AND CORRECTIONS (3)
- 471. LEGAL RIGHTS, DUTIES, LIABILITIES OF CRIMINAL JUSTICE PERSONNEL (3)
- 472. CRIME AND THE AMERICAN COURT SYSTEM (3)
- 482. SEMINAR, CRIMINAL JUSTICE AGENCY ADMINISTRATION (3)
- 490. ADVANCED FIELD WORK IN ADMINISTRATION OF JUSTICE (4)
- 491. SEMINAR — FIELD WORK IN ADMINISTRATION OF JUSTICE (2)
- 492. PROFESSIONAL FIELD THESIS IN ADMINISTRATION OF JUSTICE (4)

- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

AGRICULTURE, GENERAL (AG)

- 400. INTRODUCTORY BIOMETRY (3)
- 430. INTERNSHIP (1-10)

AMERICAN STUDIES (AM ST)

- 402. SEMINAR IN AMERICAN STUDIES (3-9)
- 405. ETHNICITY AND THE AMERICAN EXPERIENCE (3)
- 501. THEORY AND METHODS OF AMERICAN STUDIES (3) Theory and methods for the analysis of American culture: history of ideas, analysis of myth and symbol, comparative arts, etc.
- 502. PROBLEMS IN AMERICAN STUDIES (3-6) A variable-content course, addressed each term to a specific problem, topic, or period in American culture.
- 596. INDIVIDUAL STUDIES (1-6)

ANIMAL SCIENCE (AN SC)

- 422. QUANTITATIVE INHERITANCE AND ANIMAL BREEDING (3)
- 455. ANIMAL GENETICS (2)
- 464. ANIMAL BEHAVIOR — SOCIOBIOLOGY (3)

APPLIED MATHEMATICS (A M)

- 417. (Math. 417) TENSOR ANALYSIS (3)
- 418. (Math., Stat. 418) DISCRETE PROBABILITY THEORY (3)
- 419. (Math., Phys. 419) THEORETICAL MECHANICS (3)
- 431. (Math. 431) ORDINARY DIFFERENTIAL EQUATIONS (3)
- 432. (Math. 432) FOURIER SERIES AND PARTIAL DIFFERENTIAL EQUATIONS (3)
- 433. (Math. 433) OPERATIONAL MATHEMATICS (3)
- 441. (Math. 441) MATRIX ALGEBRA (3)
- 451. (Math. 451) ADVANCED CALCULUS FOR ENGINEERS I: REAL VARIABLES (3)
- 452. (Math. 452) ADVANCED CALCULUS FOR ENGINEERS II: COMPLEX ANALYSIS (3)
- 461. (Math., Phys. 461) THEORETICAL MECHANICS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 504. (Math. 504) OPTIMIZATION THEORY (3) Least squares problems, min-max game theory, global theory of constrained optimization, iterative methods of optimization. Prerequisite: Math. 420.
- 505. (Math. 505) INTEGRAL EQUATIONS (3) Fredholm and Volterra equations, and applications. Prerequisite: A.M. (Math.) 431 or 432 or Math. 420.
- 506. (Math. 506) DISTRIBUTIONS AND GENERALIZED FUNCTIONS (3) Schwartz-Sobolev theory of distributions, tempered distributions, Fourier transforms, fundamental solutions of ordinary and partial differential equations; applications. Prerequisite: A.M. (Math.) 431 or 432 or Math. 420.
- 507. (Math. 507) CALCULUS OF VARIATIONS AND OPTIMAL CONTROL (3) Classical and modern theory of the calculus of variations; problems in optimal control. Prerequisite: A.M. (Math.) 431 or 432 or Math. 420.
- 512. (Stat. 512) INTRODUCTION TO STOCHASTIC PROCESSES (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. 409 or A.M. (Stat., Math.) 418.

513. (Stat. 513) INTRODUCTION TO STOCHASTIC PROCESSES (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: A.M. (Stat.) 512.

515. (Math. 515) PARTIAL DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations with reference to physical applications. Prerequisite: A.M. (Math.) 431 or 432.

516. (Math. 516) ADVANCED PARTIAL DIFFERENTIAL EQUATIONS (3) Elliptic operators, fundamental solutions, weak and strong derivatives, Sobolev inequalities, Dirichlet problem, equations of evolution, semi-groups. Prerequisite: A.M. (Math.) 515.

560-561. (Math. 560-561) ORDINARY DIFFERENTIAL EQUATIONS (3 each) Linear spaces and operators, existence and uniqueness of solutions, linear systems, Green's functions, eigenvalue problems—including Fourier series. Prerequisite: Math. 72 or 250 or 383 or A.M. (Math.) 431.

573. SPECIAL TOPICS (2-12) Various topics according to instructor and students. Prerequisite: second-year graduate standing.

THE ARTS (ARTS)

400. CONTEMPORARY FORMS IN THE ARTS (3)

496. INDEPENDENT STUDIES (1-12)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

BEHAVIORAL SCIENCE (BEHSC)

410. BIostatISTICS (2)

501. BEHAVIORAL SCIENCE (3) Integration of biopsychosocial substrates of behavior, variability in behavior, growth and development, and behavioral correlates of disease and health.

502. BEHAVIORAL SCIENCE (2) Continued integration of biopsychosocial substrates with emphasis on adaptation, growth and development, and behavioral correlates of disease and health.

503. HEALTH BEHAVIOR AND HUMAN ECOLOGY (3) Behavioral substrates with emphasis on health behavior, human ecology, stress, behavioral factors in disease, society, prevention, and health systems. Prerequisite: Beh.Sc. 502.

511. MEDICAL STATISTICS AND RESEARCH DESIGN (2) Use of theoretical and applied statistics in medical research design and in the interpretation of data.

531. BEHAVIORAL AND PHYSIOLOGICAL CORRELATES OF STRESS (3) Effects of stress on all physiological processes; role of learning, cognition, personality, and culture in adapting to stress.

533. BIOFEEDBACK AND THE CONTROL OF INTERNAL RESPONSES (2) Discusses theoretical and clinical applications of voluntary control over EEG, cardiovascular and muscle activity, body temperature, and other physiological processes.

535. NERVOUS SYSTEMS AND BEHAVIOR (3) Synthesis of behavioral science, neurobiology, and physiology with emphasis on integrative functions of peripheral, central, and autonomic nervous systems.

537. MECHANISMS OF MEMORY (2) Discussion of physiological mechanisms involved in information storage and retrieval. Experimental design in memory research is emphasized.

551. HEALTH, ILLNESS, AND CULTURE (3) A medical sociology seminar devoted to the socio-cultural aspects of health and sickness.

555. BEHAVIOR CHANGE (3) Review of behavioral science research and theory relevant for behavior change procedures used in medicine.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

BIOLOGICAL HEALTH (B H)

401. BEHAVIORAL CONCEPTS AND HEALTH INTERVENTION (3)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

BLACK STUDIES

Students who wish to take courses in black studies may select from the following: Anthy. 424, 447; Com.D. 407, 419; C.Lit. 422, 423; C.F.Ed. 466; Econ. 424, 461; Fr. 458; Geog. 444; Hist. 459, 477, 478; Pl.Sc. 453, 454; Soc. 415, 419.

CHINESE (CHNS)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

COMMUNITY DEVELOPMENT (COM D)

402. POLITICS, POLICY, AND COMMUNITY ACTION (3)

404. COMMUNITY DEVELOPMENT THROUGH PLANNED CHANGE (3)

405. COMMUNITY MENTAL HEALTH: AN ECOLOGICAL APPROACH TO HUMAN SERVICES (3)

407. COMMUNITY CONFLICT THEORY (3)

417. IDENTIFYING COMMUNITY POWER STRUCTURES (3)

419. COMPARATIVE COMMUNITY DEVELOPMENT (3)

421. AGING AND SOCIAL POLICY (3)

433. PLANNING OF COMMUNITY SERVICE PROGRAMS (3)

434. EVALUATION OF COMMUNITY SERVICE PROGRAMS (3)

435. COST-EFFECTIVENESS ASSESSMENT OF COMMUNITY SERVICE PROGRAMS (3)

450. COMMUNITY SERVICES STUDIO (1-6)

490. ADVANCED FIELD WORK (4)

491. SEMINAR — FIELD WORK IN COMMUNITY DEVELOPMENT (2)

492. RESEARCH IN FIELD WORK (4)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

CULTURAL FOUNDATIONS OF EDUCATION (CF ED)

415. (Anthy. 415) ANTHROPOLOGY OF EDUCATION (3)

416. (Soc. 416) SOCIOLOGY OF EDUCATION (3)

417. PHILOSOPHIC BASIS OF EDUCATION (3)

418. HISTORY OF EDUCATION IN THE UNITED STATES (2-3)

419. HISTORY OF EDUCATION IN ANCIENT AND MEDIEVAL TIMES (3)

422. INTRODUCTION TO COMPARATIVE EDUCATION (3)

425. EDUCATION IN AFRICA (3)

466. RACE, POVERTY, AND THE SCHOOLS (3)

515. EXPERIMENTALIST PHILOSOPHIES OF EDUCATION (2-3) John Dewey's educational philosophy and later formulations by Bode, Kilpatrick, Childs, Brameld, and others. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

516. TOPICAL SEMINAR ON SCHOOL AND SOCIETY (2-6) An intensive and comprehensive analysis of one selected aspect of the relationship of educational institutions to their societal setting. Prerequisite: C.F.Ed. 416.

519. CONTEMPORARY PHILOSOPHIES OF EDUCATION (2-3) Implications for education of various types of realism, idealism, existentialism, and analytic philosophy. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

521. EDUCATION IN THE LATIN-AMERICAN COUNTRIES (2-3) Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina. Prerequisite: C.F.Ed. 422 or 6 credits in Latin-American studies.

522. COMPARATIVE EUROPEAN EDUCATION (2-3) Educational policies and practices in school systems in western and central European nations. Prerequisite: C.F.Ed. 422.

524. EDUCATION IN COMMUNIST COUNTRIES (2-3) Educational policies and practices in Soviet Russia and other Communist countries. Prerequisite: C.F.Ed. 422 or 6 credits in Russian or Asian studies.

526. EDUCATION IN DEVELOPING COUNTRIES (2-3) Educational problems and trends in selected countries, with particular reference to Africa, the Middle East, and Southeast Asia. Prerequisite: C.F.Ed. 422 or 6 credits in Asian, African, or Latin-American studies.

532. SOCIAL CHANGE, CULTURAL DYNAMICS, AND EDUCATION (2-3) The social role of the school in a rapidly changing society. Prerequisite: C.F.Ed. 416.

534. READINGS IN PHILOSOPHY OF EDUCATION (1-6) Selected philosophic writings — classic, modern, or contemporary — on education. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

536. EDUCATIONAL LEADERS AND CLASSICS (2-3) Selected leaders and their writings, with emphasis on historical-social context, including Quintilian, Erasmus, Comenius, Fénelon, Pestalozzi, and Mann.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

EARTH AND MINERAL SCIENCES (EM SC)

420. (S.T.S. 420) ENERGY AND MODERN SOCIETY (3)

596. INDIVIDUAL STUDIES (1-6)

EAST ASIAN STUDIES (EA ST)

401. EAST ASIAN STUDIES (3-6)

ENGINEERING (ENGR)

410. (S.T.S. 410) TECHNOLOGY: ITS CHARACTER, ROLE, AND FUNCTION (3)

450. PATENT FUNDAMENTALS (3)

500. SPECIAL TOPICS IN ENGINEERING (1-3)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-2 per term, maximum of 6)

ENVIRONMENTAL RESOURCE MANAGEMENT (E R M)

400. SENIOR SEMINAR (1)

410. POLLUTION OF ENVIRONMENTAL SYSTEMS (3)

411. LEGAL ASPECTS OF RESOURCE MANAGEMENT (3)

412. RESOURCE SYSTEMS ANALYSIS (3)

413. CASE STUDIES IN ECOSYSTEM MANAGEMENT (3)

430. INTERNSHIP IN ENVIRONMENTAL RESOURCE MANAGEMENT (1-10)

496. INDEPENDENT STUDIES (1-12)

497. SPECIAL TOPICS (1-6)

FOLKLORE (FOLK)

- 400. THEORY AND TECHNIQUES OF FOLKLORE (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

GERONTOLOGY

In several programs students may select gerontology or adult development and aging as an area of specialization — in the behavioral and social sciences, in the biological sciences, and in certain professional programs. No major or degree in gerontology is offered. Information may be obtained from the Gerontology Center, S-211 Henderson Human Development Building.

HEALTH PLANNING AND ADMINISTRATION (H P A)

- 410. PRINCIPLES OF PUBLIC HEALTH ADMINISTRATION (3)
- 420. ENVIRONMENTAL HEALTH (3-6)
- 430. PRINCIPLES OF HEALTH PLANNING (3)
- 431. HEALTH PLANNING METHODS (3)
- 432. HEALTH SYSTEMS MANAGEMENT (3)
- 433. HEALTH SYSTEMS THEORY (3)
- 440. EPIDEMIOLOGIC BASIS FOR PLANNING (3)
- 445. (Econ. 445) HEALTH ECONOMICS (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

HUMAN DEVELOPMENT (H DEV)

- 401. PROFESSIONAL ISSUES IN HUMAN DEVELOPMENT (1-3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)
- 499. SENIOR THESIS (1-10)

516. METHODS OF RESEARCH IN HUMAN DEVELOPMENT (1-6) Review of problems and techniques of research in human development.

517. MULTIVARIATE STUDY OF CHANGE AND HUMAN DEVELOPMENT (3) Models of development and change derived from empirical research utilizing multivariate research design and procedures. Prerequisites: at least three statistics courses, including correlation and regression analysis.

HUMANITIES (HUMAN)

- 471. HUMANISTIC STUDIES (1-4)
- 490. (C.&S. 490) HUMANITIES FOR TEACHERS (3)

DOCTORAL MINOR OPTION IN THE HUMANITIES

Doctoral candidates may pursue an individualized program of study leading to a certificate minor or option (15-18 credits) in a broadly interdisciplinary area in the humanities. This program will normally provide teaching experience in an area of the humanities, and certification will be granted by the College of the Liberal Arts.

INTERDISCIPLINARY PROGRAM IN THE HUMANITIES

Qualified students who wish to receive a Ph.D. degree in one of the graduate major programs in the College of the Liberal Arts or the College of Arts and Architecture, and yet would like to receive an interdisciplinary education, may enter the interdisciplinary program in the humanities after they have

been properly enrolled in one of the major programs, provided their interdisciplinary interest lies within the realm of the humanities.

INTERNATIONAL UNDERSTANDING (INT U)

400. WORLD AFFAIRS AND INTERNATIONAL UNDERSTANDING (3-6)

ITALIAN (IT)

415. DANTE (3)
420. PETRARCA AND BOCCACCIO (3)
425. THE LITERATURE OF THE ITALIAN RENAISSANCE 7(3)
450. NINETEENTH-CENTURY ITALIAN LITERATURE (3)
460. TWENTIETH-CENTURY ITALIAN LITERATURE (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

588. SEMINAR IN ITALIAN LITERATURE (3-12) Common and individual research in special problems.

JAPANESE (JAPNS)

496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

LABOR STUDIES (L S)

400. COMPARATIVE INDUSTRIAL RELATIONS SYSTEMS (3)
404. COLLECTIVE BARGAINING TRENDS (3)
411. TRADE UNION ADMINISTRATION (3)
413. (Econ. 413) COMPARATIVE LABOR MOVEMENTS (3)
414. (Econ. 414) THEORIES OF THE LABOR MOVEMENT (3)
433. THE LAW OF LABOR-MANAGEMENT RELATIONS (3)
435. LABOR RELATIONS IN THE PUBLIC SECTOR (3)
437. IMPASSE RESOLUTION IN LABOR RELATIONS (3)
454. (Soc. 454) INDUSTRY AND THE COMMUNITY (3)
455. (Soc. 455) THE SOCIOLOGY OF WORK (3)
458. (Hist. 458) HISTORY OF AMERICAN ORGANIZED LABOR SINCE 1877 (3)
496. INDEPENDENT STUDIES (1-12)
497. SPECIAL TOPICS (1-6)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

LANDSCAPE ARCHITECTURE (LARCH)

431. LANDSCAPE DESIGN — AREA ANALYSIS (3)
432. LANDSCAPE DESIGN — SITE ANALYSIS (3)
433. LANDSCAPE DESIGN — DETAIL ANALYSIS (3)
434. PARK FACILITY PLANNING AND EVALUATION (3)
435. LANDSCAPE CONSTRUCTION MATERIALS (3)
437. BASIC LANDSCAPE CONSTRUCTION (3)
439. ADVANCED LANDSCAPE CONSTRUCTION (3)
441. LANDSCAPE DESIGN — DETAIL DESIGN (3)
442. LANDSCAPE DESIGN — AREA DESIGN (3)
443. LANDSCAPE DESIGN — SITE DESIGN (3)

- 444. LANDSCAPE ARCHITECTURE FIELD TRIP (1)
 - 451. COMPREHENSIVE LANDSCAPE DESIGN I (4)
 - 452. COMPREHENSIVE LANDSCAPE DESIGN II (4)
 - 453. COMPREHENSIVE LANDSCAPE DESIGN III (4)
 - 457. PROFESSIONAL PRACTICE (2)
 - 458. ADVANCED LANDSCAPE COMMUNICATIONS (2)
 - 471. PARK PLANNING THEORY AND CONCEPTS (2)
 - 472. PLANNING AND PUBLIC POLICY (3)
 - 473. RECREATION RESOURCE PLANNING (3)
 - 474. SITE ENGINEERING FUNDAMENTALS (1)
 - 475. PARK SYSTEMS PRACTICUM (1)
 - 491. LANDSCAPE SEMINAR I (1)
 - 492. LANDSCAPE SEMINAR II (1)
 - 493. LANDSCAPE SEMINAR III (1)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
 - 499. FIELD EXPERIENCE (1-3)
-
- 518. ADVANCED PROBLEMS IN LANDSCAPE DESIGN (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects.
 - 521. TECHNICAL LANDSCAPE ARCHITECTURAL PRACTICES (2-12) Specific technical and professional problems in landscape architectural planning and practice.
 - 596. INDIVIDUAL STUDIES (1-6)
 - 597. SPECIAL TOPICS (1-6)

LIBERAL ARTS (L A)

- 400. CHANGING LIFE STYLES (1)
 - 460. UNDERGRADUATE INTERNSHIP (1-6)
 - 461. ACADEMIC ADVISER TRAINING (1)
 - 470. UNDERGRADUATE FIELD EXPERIENCE OR PRACTICUM (1-12)
 - 480. (S.T.S. 480) TECHNOLOGICAL CHANGE AND HUMAN VALUES (3)
 - 481. (Sp.Com. 481) COMPUTER APPLICATIONS TO COMMUNICATION STUDIES (3)
 - 482. QUANTITATIVE METHODS FOR HUMANISTS I (3)
 - 483. QUANTITATIVE METHODS FOR HUMANISTS II (3)
 - 484. (Engl. 484) COMPUTATIONAL AND QUANTITATIVE STYLISTICS (3)
 - 496. INDEPENDENT STUDIES (1-12)
 - 497. SPECIAL TOPICS (1-6)
-
- 582. APPROACHES TO PROBLEM SOLVING FOR HUMANISTS (3) A consideration of systematic individual and group approaches to problem solving and evaluation techniques. Prerequisite: introductory statistics.
 - 596. INDIVIDUAL STUDIES (1-6)

LITHUANIAN (LITH)

- 500. STRUCTURE OF LITHUANIAN (3) Analysis of the phonology, morphology, and syntax of Lithuanian; comparative linguistic study of Balto-Slavic and Indo-European. Prerequisite: one graduate course in linguistics.

MATERIALS SCIENCE (MATSC)

- 401. MATERIALS SCIENCE FOR TEACHERS I (3)
- 404. PROCESS MEASUREMENT AND CONTROL (1-3)
- 406. INTRODUCTION TO BIOMEDICAL MATERIALS (3)

408. (Geosc. 4m8) X-RAY DIFFRACTION (3)
 411. (Geosc. 411) INSTRUMENTAL TECHNIQUES APPLIED TO MATERIALS AND MINERAL SCIENCE PROBLEMS (1-6)

Unit A. X-RAY DIFFRACTION

Unit B. TRANSMISSION ELECTRON MICROSCOPY

Unit C. SPECTROSCOPY

Unit D. ELECTRON MICROPROBE ANALYSIS

Unit E. SCANNING ELECTRON MICROSCOPY

Unit F. ABSORPTION SPECTROSCOPY

Unit G. ION BEAM TECHNIQUES

412. QUANTITATIVE MICROSTRUCTURAL AND PARTICULATE CHARACTERIZATION (1)
 416. MATERIALS PREPARATION (2)
 420. MATHEMATICAL MODELING FOR MATERIALS SCIENTISTS (3)
 490. SPECIAL TOPICS IN MATERIALS SCIENCE (1-9)
 496. INDEPENDENT STUDIES (1-12)
 497. SPECIAL TOPICS (1-6)

501. THERMODYNAMICS OF MATERIALS (3) Application of thermodynamics to materials equilibria and processes, including solution theory, electrochemical processes, capillarity, and the effect of stresses. Prerequisite: Chem. 451.

503. (G.M. 503) KINETICS OF MATERIALS PROCESSES (3) Introduction to application of transition state theory and mass transfer to the kinetics of materials and mineral processes. Prerequisites: Math. 100; Chem. 451; Mat.Sc. 501 or G.M. 521.

512. (G.M. 512) PRINCIPLES OF CRYSTAL CHEMISTRY (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions.

514. CHARACTERIZATION OF MATERIALS (3) Classical and new (microprobe, scanning microscope, magnetic resonance, and Mossbauer) techniques for the characterization of composition, structure, defects, and surfaces.

524. (G.M. 524) VIBRATIONAL SPECTRA OF MATERIALS AND MINERALS (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization, and glass research. Prerequisites: Phys. 412, 471.

531. (G.M. 531) TRANSMISSION ELECTRON MICROSCOPY (2) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences. Prerequisite: Mat.Sc. 411B (Geosc. 411B).

532. (G.M. 532) STRUCTURE ANALYSIS (2) Crystal structure determination methods; space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Mat.Sc. 408 (Geosc. 408).

533. (G.M. 533) SINGLE CRYSTAL METHODS (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Mat.Sc. 408 (Geosc. 408).

534. (G.M. 534) DIFFRACTION BY CRYSTALS (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescence, polarization. Prerequisite: Mat.Sc. 408 (Geosc. 408).

535. (G.M. 535) GEOMETRICAL CRYSTALLOGRAPHY (3) Derivation of lattices, types, point groups, and space groups, with applications.

538. (G.M. 538) ELECTRON BEAM ANALYSIS OF SOLIDS VIA X-RAY AND ELECTRON EMISSION (3) Theory of phenomena occurring in electron- bombarded solids and their applications to analysis of solids.

540. CRYSTAL ANISOTROPY (3) Symmetry aspects of crystals and physical properties. Matrix and tensor methods. Prerequisite: Phys. 412.

542. **MAGNETIC METHODS IN MATERIALS SCIENCE (3)** Static magnetic (susceptibility type) and spectroscopic methods (nuclear and electron magnetic resonance, Mossbauer spectroscopy) for materials characterization and structural analysis. Prerequisite: Phys. 413.

552. **THEORY AND PRACTICE OF CRYSTAL GROWTH (3)** Theoretical approaches to crystal growth and of the various techniques used in growing crystals.

554. **ELECTRONIC SPECTRA OF MATERIALS (3)** Crystallographic and thermodynamic applications of crystal field theory. Electronic spectra of crystals and glasses. Luminescent spectra and phosphor characterization. Prerequisite: Phys. 471.

570. **CATALYTIC MATERIALS (3)** Preparation and characterization of solid catalytic materials. Relationships between their surface, defect, and electronic properties and catalytic activity. Prerequisite: Chem. 452.

596. **INDIVIDUAL STUDIES (1-6)**

597. **SPECIAL TOPICS (1-6)**

MINERAL ENGINEERING (MIN E)

414. **PLANNING AND CONTROL FOR THE MINERAL INDUSTRIES (3)**

415. **MANAGEMENT IN THE MINERAL INDUSTRIES FOR ENVIRONMENTAL, LEGAL, AND HEALTH AND SAFETY PROBLEMS (3)**

496. **INDEPENDENT STUDIES (1-12)**

497. **SPECIAL TOPICS (1-6)**

PATHOLOGY (PATH)

501. **PRINCIPLES OF PATHOLOGY (4)** The fundamentals of reaction to injury at cellular and tissue levels emphasizing the pathogenesis of functional, structural, and biochemical abnormalities.

520. **BIOLOGY OF NEOPLASIA (3)** Detailed examination of the initiation and pathogenesis of animal neoplasms with emphasis on the relationship to human neoplasia. Prerequisite: admission to College of Medicine.

522. **CANCER IMMUNOLOGY AND IMMUNOTHERAPY (2)** Detailed study of recent advances in host response to malignancy in man and experimental animals. Prerequisite: Path. 501 or Micrb. 554.

597. **SPECIAL TOPICS (1-6)**

PEDIATRICS (PED)

525. **CLINICAL GENETICS (5-10)** Mendelian and molecular principles of human genetics; genetic bases of human disease, quantitative human genetics, prenatal diagnosis, genetic counseling.

526. **HUMAN CYTOGENETICS (2)** Human chromosome identification; structure, replication, and evolution of human and other eukaryotic chromosomes in cytogenetic and molecular terms.

PLANT SCIENCE (PLTSC)

400. **PRINCIPLES OF PLANT SCIENCE RESEARCH (2)**

496. **INDEPENDENT STUDIES (1-12)**

497. **SPECIAL TOPICS (1-6)**

POPULATION ISSUES

Qualified students may select population issues studies as an option of specialization when majoring in economics, geography, sociology, anthropology, rural sociology, or agricultural economics. Additional information is given under the description of those majors in the preceding section.

PORTUGUESE (PORT)

- 456. BRAZILIAN LITERATURE IN ENGLISH TRANSLATION (3)
- 496. INDEPENDENT STUDIES (1-12)
- 497. SPECIAL TOPICS (1-6)

588. SEMINAR IN PORTUGUESE AND BRAZILIAN LITERATURE (3-12) Common and individual research in special problems.

SCIENCE (SC)

- 400. CONSEQUENCES OF SCIENCE (1)

SCIENCE, TECHNOLOGY, AND SOCIETY (S T S)

- 410. (Engr. 410) TECHNOLOGY: ITS CHARACTER, ROLE, AND FUNCTION (3)
- 420. (E.M.Sc. 420) ENERGY AND MODERN SOCIETY (3)
- 430. FOOD AND MAN: TECHNOLOGY AND FEEDING THE WORLD POPULATION (3)
- 432. (Phil. 432) MEDICAL ETHICS (3)
- 435. (Phil. 435) THE INTERRELATION OF SCIENCE, PHILOSOPHY, AND RELIGION (3)
- 460. SCIENCE AND PUBLIC POLICY (3)
- 470. TECHNOLOGY ASSESSMENT AND INDICATORS OF THE QUALITY OF LIFE (3)
- 471. RADIATION, REACTORS, AND SOCIETY (3)
- 480. (L.A. 480) TECHNOLOGICAL CHANGE AND HUMAN VALUES (3)
- 496. INDEPENDENT STUDIES (1-12)

NOTE: This program is designed to examine critically the impact of scientific investigation and technological development on society and the influence of human needs on scientific investigation and technological development.

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